Prediction of Stress Resilience with Attentional Measures

Thesis

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Abstract

The main aim of this thesis was to investigate if individual differences in two parameters of selective attention to emotional stimuli, i.e. biased attention to positive stimuli and affective control, are predictive of stress resilience. Recent theoretical accounts suggest that these two parameters directly impact stress resilience. Prior research has consistently linked deficits in attention to emotional stimuli to stress-related disorders such as depression and anxiety. In addition, a few preliminary findings indicate that acute and chronic stress results in a decrease of attentional flexibility. In contrast, few studies have investigated how individual differences in selective attention to emotional stimuli might contribute to adaptive stress responses and resilience.

The main aim of this thesis was therefore to improve knowledge about how selective attention to emotional stimuli is related to stress resilience. Enhanced knowledge could guide prevention and treatment options for stress-related disorders.

Two empirical articles are presented in this thesis. The first article concerns the predictive value of biased attention to emotional stimuli on trait stress resilience. 43 healthy participants completed a modified dot probe task measuring biased attention to emotion (positive, negative) together with measurement of trait stress resilience. The second article concerns the predictive value of affective control on stress resilience and emotional reactivity to a laboratory stressor. In two studies, 48 and 61 healthy participants completed an affective control task with measurements of trait resilience and emotional responses to a laboratory stressor.

This thesis discusses the theoretical background and prior experimental evidence pertaining to stress resilience and selective attention in the light of biased attention to emotional stimuli and affective control as potentially modifying individual differences in stress resilience. The discussion is centered on possible consequences of these two aspects of

selective attention in relation to stress resilience and stress-related psychopathology. The first part of the thesis is concerned with models and measurements of resilience. The second part addresses models and measurement of biased attention and affective control. In the third part, possible pathways between resilience and selective attention to emotional stimuli are outlined. In the fourth part, the three empirical studies are presented. Finally, the results are discussed in the light of prior findings, methodological issues are contemplated, and future directions are suggested.

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Abbreviations

A

α	Alpha value
AB	Attentional bias
ABM	Attentional bias modification
ACC	Accuracy
ADHD	Attention deficit/hyperactivity disorder
ACC	Anterior cingulated cortex
AIDS	Acquired immunodeficiency syndrome
AIS	American institute of stress
ANOVA	Analysis of variance

B

β	Standardized beta value
B	Beta value
BRS	Brief resilience scale

C

CC	Current congruent trial following congruent trial
CD-RISC	Connor-Davidson resilience scale
CI	Current incongruent trial following congruent trial

D

DPT	Dot-Probe task
DRD4	Dopamine receptor D_4
DSM-IV	Diagnostic and statistical manual of mental disorders- IV

E

EEG	Electroencephalography

F

fMRI	Functional magnetic resonance camera
FG	Fusiform gyrus

G

G x E	Gene x Environment
GAD	Generalized anxiety disorder
GES	Goal engagement system

H

5-HTTLPR	Serotonin transporter linked polymorphic region
HPA	Hypothalamus pituitary adrenal axis

I

IC	Current congruent trial following incongruent trial
II	Current incongruent trial following incongruent trial
IoR	Inhibition of return

J

K

L

LGMM	Latent growth mixture modeling
LGN	Lateral geniculate nucleus

M

M	Mean
MDBF	Multidimensional mood state questionnaire
MT	Middle temporal area
ms	Millisecond

N

N170	Negative 170

O

P

p	Probability value
PTE	Potentially traumatic event
PTSD	Post traumatic stress disorder
PFC	Prefrontal cortex

Q

R

RS-11	Resilience scale
RT	Response time

S

SAM	Self-assessment Manikin scale
SD	Standard deviation
SNS	Sympathetic nervous system
SNS-Lab	Laboratory of social and neural systems research
SSRI	Selective serotonin reuptake inhibitors
Std.	Standard

T

U

V

VES	Valence Evaluation System
V1	Primary Visual Cortex
V2	Secondary Visual Cortex
V3	Visual association cortex 3
V4	Visual association cortex 4
V5	Visual association cortex 5

X

Y

Z

Figures and Tables

Outline and aims of this thesis

The aim of this thesis was to assess the relation between mechanisms of selective attention to emotional stimuli on resilience. The first part of the work consisted an experimental study, examining biased attention to emotional (positive, negative) stimuli with resilience in healthy participants. In the second part, two experimental studies were conducted, examining affective control with resilience in healthy participants.

This thesis is organized as follows:

Chapter 1 – Introduction – The introduction outlines the integrated theoretical framework under which the research in this thesis was carried out.

Chapter 2 – Describes models and measurement methods of resilience.

Chapter 3- Describes models and measurement methods of attentional biases and affective control

Chapter 4 – Describes possible pathways between resilience and selective attention to emotional stimuli

Chapter 5 – Empirical studies – describe the experimental work: the aims, the hypothesis or models tested the set up and the outcomes of four studies. The specific goals of each study were the following:

• To investigate the predictive value of biased attention to emotional stimuli on self-rated trait resilience.

• To investigate the predictive value of affective control on self-rated trait resilience.

• To investigate the predictive value of affective control on self-rated emotion responses to a laboratory stressor.

Chapter 6 – General Discussion and Conclusion – provides a general discussion and conclusion of this work; presents its contributions to the field; and indicates directions for future research

Introduction

Most individuals experience at least one traumatic event during their lifetime (Norris, 1992; Norris & Sloane, 2007). In addition to traumatic events, many of us face chronic stressors at some point in our life, be it in the form of monetary need, juggling many life-roles at the same time, illness, or family conflicts. Although some of us will react to those stressors with heightened levels of psychopathology, such as anxiety and depression (Rutter, 1987), or somatic symptoms as upset stomach, insomnia and weakened immune system (McEwen & Sapolsky, 2006), most will manage to meet such challenges in an adaptive way and find their way through the event or stressful period with preserved function and without experiencing illnesses (Bonanno, 2004; 2005; Bonanno, Westphal & Mancini, 2011). When we adapt well in the face of different sources of stress, we are experiencing or expressing something called resilience (American Psychological Association, 2013). Each person has their own unique way of expressing resilience, and we might be more or less resilient depending on the specific circumstances surrounding a stressful event or period. This is due to that resilience stem from a multitude of interacting factors that might change over the lifespan (Charney & Southwick, 2012). Such varying factors related to resilience include for instance socioeconomic status, health, and social support (Bonanno et al., 2011; Hobfoll, 2001; Rutter, 1987).

Two factors that vary over individuals and that are strongly related with resilience are (1) the amount of positive emotion during and in the aftermath of the stressor, (Tugade & Fredrickson, 2004; Ong, Bergeman, Bisconti, & Wallace, 2006) and, (2) the ability to identify, realistically evaluate, and face emotional stimuli, and in particular threats (e.g., Southwick & Charney, 2011). It has been suggested that these two factors depend in part on individual differences in two mechanisms of selective attention, namely attentional biases to positive stimuli and affective control (Gross, 1998; Ochsner & Gross, 2005; Todd, Cunningham, Anderson, & Thompson, 2012; Troy & Mauss, 2011).

Individuals that are more prone to attend to certain stimuli, such as positive stimuli, are said to exhibit an attentional bias (AB) to such stimuli (Duncan, 2006; Todd et al., 2012). ABs are linked not only to higher attention to specific stimuli, but stimuli also function as "triggers" of further reactions. Such reactions may include emotions, cognitions and behaviors (Ehlers & Clark, 2000; Matsumo & Ekman, 2010; Scherer & Ceschi, 1997). For instance, higher AB to positive stimuli in a stress situation might lead to increased experience of positive emotions and cognitions together with reward directed behavior (Yiend, 2010).

Prior research consistently links a higher AB to negative stimuli with stress-related pathologies such as anxiety (Bar-Haim, Lamy, Pergmain, Bakermans-Kranenburg, & van IJzendoorn, 2007) and depression (Peckham, McHugh, & Otto, 2010). In addition, an AB *away* from positive stimuli has been found in depression (Armstrong & Oljatunji, 2013). Preliminary findings also suggest that higher AB to positive stimuli is associated with low anxiety (Frewen, Dozois, Joanisse, & Neufeld, 2008), low vulnerability to depression (Joorman, Talbot, & Gotblib, 2007) and more experience of positive emotions (Ong et al., 2006; Tamir & Robinson, 2007). These results suggest that more biased attention to positive stimuli might be related to better stress adaptation. However, these studies used indirect measures of resilience, such as absence of psychopathology (e.g., Frewen et al., 2008). The first study in this thesis therefore directly assessed the relationship between biased attention to positive stimuli and stress resilience.

Affective control is the ability to keep task focus in emotional situations and disregard emotional distracters (e.g., Egner, 2007). The typical promotion of emotional stimuli observed in attentional processing is thought to be adaptive since such stimuli might carry important information about threats and rewards (e.g., Ohman, Flykt, & Esteves, 2001; LeDoux, 2000; Reeck, LaBar, & Egner, 2012). However, individual with lower affective control cannot direct attention away from irrelevant emotional distracters, leading to decreased ability to disengage from irrelevant rewards and threats (Ossewarde, Qin, Van Marle, van Wingen, Fernandez, & Hermans, 2010). Failure to recruit affective control in conflict situations (i.e., situations with conflicting emotional stimuli) can be detrimental for the individual. For instance, the prolonged elaboration of negative internal stimuli typically seen in depressed subjects has been related with deficits in affective control (Goeschke, 2013). Further, affective control may be of particular importance in stressful situations as such situations are highly emotional (Sarason, Johson, & Siegel, 1978).

Even though the need for control increases in stressful situations, the typically finding is a decrease of attentional control during acute and chronic stress (Liston, McEwen, & Casey, 2009; Plessow, Fischer, Kirschbaum, & Goscheke, 2011). Failure of attentional control, leading to higher attention to distracters, has been found to increase non-adaptive coping, such as over-eating (Miller & Cohen, 2001; Ossewarde et al., 2010) and increased worry and intrusions (e.g., Hagenaars & Putman, 2011; Verwored, de Jong, & Wessel, 2008). However, these studies assessed the impact of stress on attentional control. In contrast, whether higher affective control lead to better stress adaptation is not well known. Further, these prior studies assessed *attentional* control to neutral stimuli. Robust findings from imaging studies suggest that control of neutral and emotional stimuli are processed in distinct circuits (for an overview see Egner, 2007). The relationship between *affective* (i.e., control of emotional stimuli) control and resilience is not well known. Two of the presented studies in this thesis therefore investigate whether higher affective control predicted higher stress resilience.

Research into stress protective aspects of selective attention to emotional stimuli is of particular interest for two main reasons, (i) research about selective attention to emotional stimuli in resilient individuals is lacking, and (ii) enhanced knowledge might lead to improved prevention and treatment of stress-related disorder (Monk, 2008; Yiend, 2010).

This thesis explores the research questions that biased attention to emotional stimuli and affective control predicts individual differences in stress resilience. The research question was explored in (1) a systematic research review, (2) three experimental studies in healthy adults, and (3) a prospective experimental study in medical students that was conducted in a functional magnetic resonance camera (fMRI) environment. Empirical papers from the three experimental behavioral studies (i.e., 2) are included in the thesis.

This thesis is organized starting with a theoretical background reviewing stress resilience (chapter 2), then models and measurements of selective attention (chapter 3), followed by an outline of the rationale of the thesis (chapter 4), thereafter two empirical papers resulting from the conducted studies are presented (chapter 5), followed by a discussion of the results and implications for future studies (chapter 6).

Chapter 2 – Resilience

It has been repeatedly shown that although the experience of stressful events are associated with an increase in psychopathology and ill health, most individual are resilient, i.e. they adapt physiologically and psychological to such events without a long-term reduction in functioning (e.g., Bonanno, 2004, Rutter, 1987; Rutter, 1999). Some individual might even show improvement of adjustment and personal growth in response to severe stress (Cohen, Kessler, & Gordon, 1997). Individual that exhibit successful psychologically and physiologically adaptation in response to stressful events are said to show resilience (Feder, Nestler, & Charney, 2009). The individual level of resilience might vary over the life-span and in different situations depending on a range of factors (Bonanno et al., 2011). Such factors include for instance age, economic and social resources, genetics and cognitive appraisals of the stressor (e.g., Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008). Recent years have seen an increase in research interest about protective and vulnerability factors and their interaction, since such factors might explain individual differences in stress resilience (e.g., Cohen et al., 1997). Knowledge of protective and vulnerability factors related to resilience could potentially lead to improvement of prevention and treatments options of stress-related disorders. It has been suggested that research about protective resilience factors is of high relevance (Yiend, 2010). Without knowledge about how protective factors operate in healthy or highly resilient individuals, guidance for treatment and prevention is missing.

This chapter introduces definitions and models of stress resilience (2.1) and available measurement methods (2.2) of resilience, including markers of resilience that are of relevance for this thesis. A brief introduction to genetic and neural markers is provided to achieve a broad picture of available measurement methods.

2.1 Definitions and models of stress resilience

The Oxford dictionary suggest the following definition of resilience "*the capacity to recover quickly from difficulties; toughness*"(see figure 1). This definition suggests that we can use individual differences in time to recover from a stressful event or trauma as a quantification of resilience. However, stressors can be diverse (e.g., chronic, acute) and stress response involves both physiological and psychological reactions (e.g., McEwen, 2007; 2010; 2012). A definition of resilience more adapted to psychological research has been suggested by Feder and colleagues (Feder et al., 2009, p.446): "*resilience refers to a person's ability to adapt successfully to acute stress, trauma or more chronic forms of adversity…and continue to demonstrate adaptive psychological and physiological stress responses or psychobiological homeostasis*".

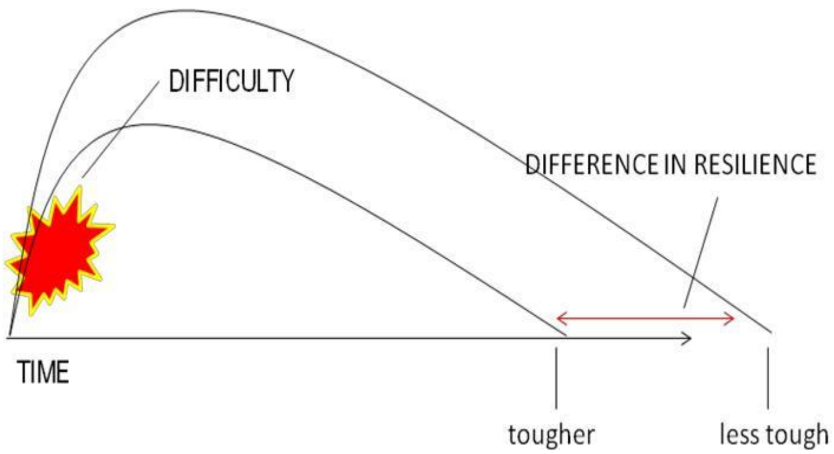
Individual differences in resilience are conceptualized in the research literature on a continuum from completely stable personality traits to a varying outcome depending on interacting factors (e.g., Bonanno et al., 2011; Connor & Davidson, 2003). Resilience is measured in response to stressors, and these can be a challenging event, a traumatic situation or chronic stressors (McEwen, 2007). Definitions of resilience vary over three major groups:

(i) absence of psychopathology following a stressful period or event

(ii) ongoing psychological and physiological functioning is adaptive during and following a stressful period or event

(iii) building of resources in the face of stress

Figure 1. Individual Differences in Resilience According to the Oxford Dictionary



Note: Adapted from the definition of resilience in the Oxford Dictionary (2013).

The uses of resilience as a construct in the research literature are not necessarily mutually exclusive. For instance, resilience defined as maintained functionality over time after a stressful event might be due to both a stable trait (i.e., resiliency) and several interacting resilience promoting factors. In this thesis it is assumed that individual differences in resilience stems from the interaction of a multitude of factors that are more or less stable over time, including for instance variations in selective attention, genetic influences, learned coping strategies, and socioeconomic circumstances. However, it is also assumed that some of these factors are relatively stable, and can be assessed with trait resilience questionnaires.

2.1.2 Distribution of stress resilience after stressful events. Several models suggest typical distributions of stress-responses and resilience after a stressful event (e.g., Belsky & Pluess, 2009; Bonanno, 2004; Norris, Tracey, and Galea, 2009). These models aim at identifying typical response patterns related to resilience in a population, which in turn enables identification of resilience factors that characterize individuals that remain resilient in the face of adversity. Such factors might stand in a causal relationship with resilience, or co-occur and thus being markers of resilience. In this section three main models of distribution of resilience after a stressful event are introduced, starting with a presentation of trajectories described by George Bonanno (2004, 2005, 2008; Bonanno et al., 2011), followed by additional trajectories from Norris et al. (Norris et al., 2009), and thereafter the differential susceptibility hypothesis suggested by Belsky and Pluess is reviewed (2009).

2.1.2.1 Trajectories by Bonanno. Bonanno suggested that responses to potentially stressful events (PTE) could be described by one of four major trajectories of responses (see figure 2); (1) resilience, (2) recovery, (3) delayed reaction, and (4) chronic distress (Bonanno, 2004; Bonanno, Moskowitz, Papa, & Folkman; Bonanno, Kennedy, Galatzer-Levy, Lude, & Elfstom, 2012a; Bonanno et al., 2011; Bonanno, Wortman, & Nesse, 2004). The model emphasizes that even though some individuals will develop a stress-related reduction of daily function after a PTE, the majority will preserve their pre-event level of function (Bonanno, 2004). A main contribution of this model is the shift in focus from psychopathology following a PTE, to a view of most people as resilient in the face of stressors. The four trajectories are defined as follows:

(1) In resilience only transistent stress reactions are exhibited (to an isolated PTE), and daily psychological and physical functioning is largely preserved in a healthy manner.

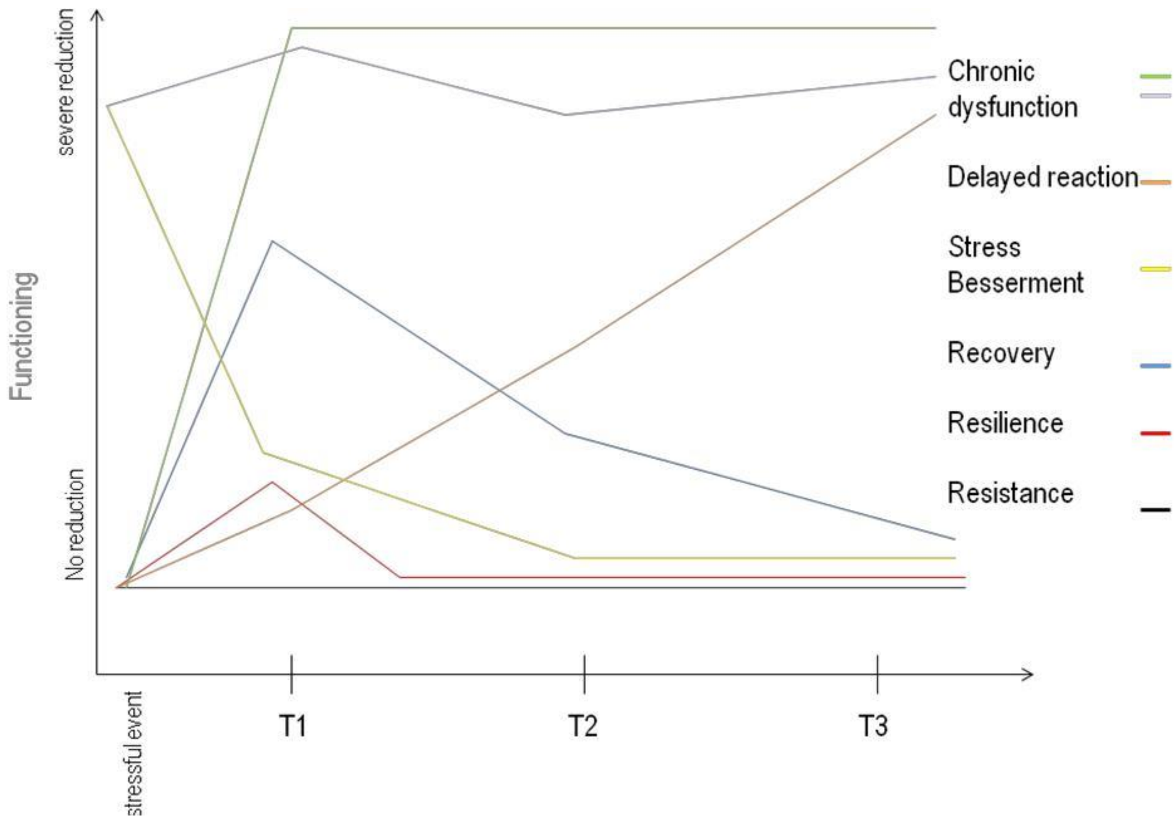
(2) Recovery is characterized by an upheaval of stress symptoms and impairment in functioning after the PTE, followed by a return to “pre PTE” levels of functioning.

(3) Delayed reaction is found when stress symptoms appear after a period of relative preserved functioning following a PTE.

(4) Chronic distress is chronic psychopathology, either preceding or following the PTE, such as posttraumatic stress disorder (PTSD).

Recently, Bonanno and colleagues (Bonanno et al., 2011) have used a statistical analysis called latent growth mixture modeling (LGMM) to identify trajectories of responses in longitudinal behavioral data. LGMM uses a mix of continuous and categorical data (mixed model) to identify trajectories of growth in a measure over time. For this reasons, this type of analysis needs longitudinal data using the same measure in the same individuals over several time points. Based on such data, LGMM models the groups that best fit the data (Muthén, 2004). Using this statistical method, Bonanno and his colleagues have analyzed longitudinal data acquired after a traumatic event such as bereavement and terrorist attacks (e.g., Galatzer-Levy & Bonanno, 2012, 2013; Bonanno et al., 2005; Bonanno et al., 2012a). These studies have confirmed that most individual stay resilient after highly stressful events, and the additional three trajectories (i.e., recovery, delayed response, and chronic distress) have also been confirmed in some if not all analyses.

Figure 2. Trajectories of Responses to a Potentially Traumatic Event

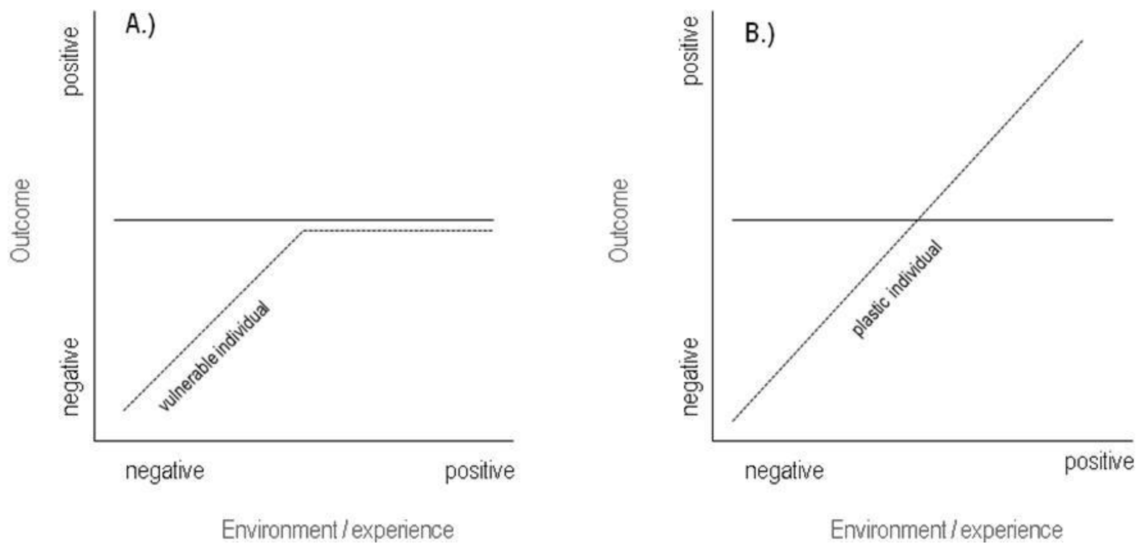


Note: Figure adapted from Bonanno, Westphal & Mancini (2011), with additional trajectories (i.e., stress improvement and resistance) suggested by Norris et al. (2009)

2.1.2.2 Additional suggested trajectories. Norris and colleagues (Norris et al., 2009) suggested two additional trajectories following a stressful event, (1) better function after than before the stressor or so called "stress-improvement", and (2) no reaction to stressor, so called resistance. In the latter case, the individual seem to cope, and daily function is unaffected. However, resistance to respond involves a suppression of all emotional reactions, and an authentic acknowledgement of the stressful event is missing (Norris et al., 2009). In addition, Bonanno et al. (Bonanno, Boerner, & Wortman, 2008) have suggested a trajectory that is characterized by continuous high distress levels that are present over a long period of time and precedes the PTE. That psychopathology and difficulties that are unrelated with a traumatic event proceed for instance the diagnosis of PTSD have been recently been confirmed in a meta analysis of prospective PTSD studies (DiGangi, Gomez, Mendoza, Jason, Keys, & Koenen, 2013). The other two suggested trajectories have also been identified in longitudinal data, for instance stress-improvement after a divorce (Clark, Diener, Georgellis, & Lucas, 2008).

2.1.2.3 Differential susceptibility model. The differential susceptibility hypothesis (Belsky & Pluess, 2009) suggests that some individuals are more sensitive or *susceptible* to environmental influences than others. This model builds on the vulnerability model, which suggests that some individuals are more sensitive to stressors than others. The differential susceptibility hypothesis has been adapted from gene x environment (G x E) interaction studies that have found specific "vulnerability - resilience genes" moderated by environmental influences, such as parental quality, to be the model that best explains resilience and development of stress related disorder. This hypothesis challenges the vulnerability model that states that some individuals are more vulnerable to stressors than others (e.g., Bakermans-Kranenburg & van IJzendoorn, 2007). Instead the differential susceptibility hypothesis suggests that not only are some individual more vulnerable to stressors, but the very same individual profit much more from beneficial environmental influences or just the absence of stressors (Belsky & Pluess, 2009) (see figure 3). Stress-vulnerability is thus not necessarily one-sidedly bad for the individual, but instead indicates plasticity (sensitivity) to *all* environmental influences (Belsky & Pluess, 2009). Plasticity is thus "a double-egged sword", on one hand rendering the individual stress-vulnerable, and on the other hand giving an enhanced ability to benefit from beneficial circumstances (Belsky & Pluess, 2009). The differential susceptibility hypothesis has crucial consequences for the resilience concept, as it states that the individuals that are less resilient after stressors outperform their more resilient peers in situations where they are allowed to flourish and benefit more from enrichments of the environment as for instance therapeutic interventions and treatments (e.g., DeRubeis, Hollon, Amsterdam, Shelton, Young, Salomon, & Gallop, 2005).

Figure 3. The Diathesis/dual Risk Model and the Differential Susceptibility Hypothesis



Note: A.) Diathesis/ dual-risk model of individual differences in stress responses, figure adapted from Bakermans-Kranenburg and van IJzendoorn's (2007); B.) Differential susceptibility hypothesis of individual differences in stress responses, figure adapted from Belsky and Pluess (2013).

This hypothesis has been motivated within from an evolutionary point of view, as quoted from Pluess and Belsky (2013) “*the idea that any form of phenotypic variation in and of itself is necessarily positive or negative is an anathema to biology*” (Cameron et al., 2005, p. 846). From an evolutionary point of view, the future impossible to predict, and the best options for any species is thus to have individuals with a range of plasticity to ensure that some individuals adapt when circumstances enfold in unpredictable directions (Pluess & Belsky, 2013).

The differential susceptibility model has found support in experimental results, including genetic, physiological, and behavioral measures (Pluess & Belsky, 2013). For example, a variation of the DRD4 gene, that plays a role in attentional and reward processed, called the 7-repeat variant, has been identified as a vulnerability factor in several studies, for instance linking it with attention-deficit/hyperactivity disorder (ADHD) (Faraone, Doyle, Mick, & Bieberman, 2001). In studies measuring vantage sensitivity (i.e., ability to improve from benign circumstances) in addition to vulnerability, a different profile emerges for the carriers of the 7-repeat variation of the DRD4 gene. For instance, a meta analysis looking at G x E interactions in dopamine related genes (including the DRD4) in children under 10 years, showed that low expressers of dopamine genes are more susceptible to environmental influences, being more negatively affected by stressors and profiting more from positive interventions (Bakermans-Kranenburg & Van IJzendoorn, 2011). The presence of the DRD4 gene in children has been found to predict if the children profit from parental intervention to reduce externalizing behavior. Only children with the DRD4 repeat-7 variation benefited from the intervention, while children carrying other variations of this gene, or control groups children, did not change their behavior (Bakermans-Kranenburg, van IJzendoorn, Pijlman, Mesman, & Juffer, 2008; Pluess & Belsky, 2013).

2.1.3 Distinguishing resilience from stress and coping. Stress, coping and resilience are partly overlapping concepts. Below are definitions of stress, coping together with an attempt to distinguish these concepts from each other.

2.1.3.1 Stress. Stress in the sense of psychological stress, is a term that was coined by Hans Seyle (1955). Seyle modeled his view of stress on a model from physics that show how material under increasing strain will become damaged, or stressed, at a certain point[1]. A more modern definition of stress states "*stress is the non-specific response of the body to any demand for change*" (American Institute of Stress, AIS; 2007). Further, Lazarus and Folkman (1984) introduced the transactional model of stress and coping (1984). This model pressed the importance of the evaluation of the demands in a potentially stressful situation together with the evaluation of available resources. If an individual evaluates that the demands of the situation is exceeding the resources, this leads to increased stress. Thus this model emphasizes the individual's appraisals of both the situation and own resources as important for the experience of stress.

However, the research field of stress has developed tremendously and stress researchers today use such a diverse set of definitions of stress that it would be difficult if not impossible to settle on one definition (Pacak & Palkovits, 2001). Based on the broad definition from the AIS, resilience is a *particular response* to stress characterized of preserved functioning in and after stressful events resulting from a multitude of interacting factors.

2.1.3.2 Coping. Another concept commonly used in stress research is coping. Coping is used to describe the wide range of strategies that an individual use to adapt to stressors. Coping as a concept is thus closely related to resilience. Cope is defined by the Oxford

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[1] Selye was born in Austria, and his mother tongue was German. He admitted that he mixed up stress and strain when due to language difficulties. When Selye wrote stress, he therefore actually meant strain (i.e., the force that strains a material).

dictionary as "(*of a person) deal effectively with something difficult*" (2013). In accord with the closeness between the concepts of resilience to coping, many of the factors that are related with psychological and physiological coping are likewise related with resilience.

2.2 Measuring resilience

Measuring resilience requires valid and reliable measurement instruments. Several options for measurement are in use, including questionnaires and physiological markers. An ideal option is to measure functioning and psychopathology at several time-points (before and) after a stressful event (e.g., Bonanno et al., 2011). However, cross-sectional investigations of resilience have their own benefits. In this section, the available measurement options of resilience are briefly presented. Questionnaires are review first followed by a chosen number of markers of resilience including psychological, genetic and neural markers of resilience. It should be made clear that markers of resilience are not direct measures of resilience. Instead, they provide insight into mechanisms underlying or related with resilience. Variation in such markers might contribute to individual differences in resilience. Markers are included under measuring resilience, because they might eventually be proxies for resilience. This section is provided to enable an evaluation of the chosen measures in the presented studies of this thesis, and is not meant to be exhaustive.

2.2.1 Questionnaire measures. Questionnaires provide a cost-effective and validated measurement of resilience (Windle, Bennett, and Noyes, 2011). Trait resilience questionnaires are of particular use in cross-sectional studies, where longitudinal measures of resilience are not an option. However, given that the research field of resilience is relatively new, no gold standard for measurement of resilience exists, and all available resilience scales have been found to require further evaluation (Windle et al., 2011). With that in mind, we can conclude that the measurements at this time point are likely to develop and become more precise over the coming years. Questionnaire measures attempt to directly assess resilience –

some questionnaires adopt a trait view (i.e., resiliency), while other questionnaires use a multi-factorial view of resilience including for instance community resources and personal competences (Windle et al., 2011).

There are fifteen validated resilience questionnaires that directly assess resilience or resiliency (excluding short-scales and revisions) in English language currently in use (Windle et al., 2011) (see table 1). A recent review found the quality of all these questionnaires to be moderate at the most, with the Connor-Davidson Resilience Scale (CD-RISC; Connor and Davidson, 2003) and the Brief Resilience Scale (BRS; Smith et al., 2008) as the best validated measures (Windle et al., 2001). The same two scales (CD-RISC and BRS) are specifically developed to measures resilience following stressful events (see table for details). In the German speaking area, one validated trait resilience questionnaire is currently in use, the Resilience Scale (RS; Wagnild & Young, 1993). The RS thus provides a relevant option when measuring resilience in the German speaking populations.

Resilience has been found to vary over different population groups. For instance resilience measured with the CD-RISC, has been estimated to 80.7 in the general American population (Conner & Davidson, 2003). In contrast, psychiatric outpatients had a mean of 68.0, while a PTSD sample had a mean of 47.5 (Conner & Davidson, 2003).

It is not advisable to compare different resilience questionnaires without considering differences in conceptualization. A recent review found that the distribution of resilience, as measured with questionnaires, varies between 25-84% over research studies, which might be due to the use of different measurement instruments (Vanderbilt-Ariance, & Shaw, 2008). It has been shown in earlier studies, that scales not yet validated produce more positive results (app. 40% more positives), and as none of the available questionnaires scales measuring resilience is satisfactory validated, there is a real need of further assessment of resilience scales (Windle et al., 2011).

Table 1. Available resilience questionnaires measuring resilience

Authors	Scale	Measuring
Barton, 1989	The Dispositional Resilience Scale	Hardiness (commitment, control and challenge), evaluates change
Block & Kremens, 1996	The Ego-Resilience Scale	Ego-resiliency, trait measure
Connor & Davidson, 2003	The Connor-Davidson Resilience Scale	Clinical measures of stress coping ability (personal competence, trust/tolerance/strengthening effects of stress, acceptance of change, secure relationship, spiritual influences)
Donnon & Hammond, 2003	Youth Resiliency: Assessing Developmental Strengths	Protective factors and developmental strengths (e.g., family, community, peers, work, commitment, school, social sensitivity, cultural sensitivity, self concept, empowerment, self control), assesses “resilience profile”
Friboug et al., 2003	The Resilience Scale for Adults	Protective factors (e.g., personal competence, social competence, family coherence, social support, personal structure), assesses “resilience profile”
Hurtes & Allen, 2001	The Resiliency Attitudes and Skills Profile	Resilience attitudes (e.g., creativity, insight, humor, values), assesses profile of intervention for youth

Oshio et al., 2003	Adolescent Resilience Scale	Psychological characteristics of Japanese Youth (novelty seeking, emotion regulation, positive future orientation)
Sun & Stewart, 2007	California Healthy Kids Survey - The Resilience Scale of the Student Survey	Student perception of individual protective resources (e.g., communication & cooperation, self esteem, empathy, problem solving, goals, family connection, autonomy, pro-social peers, meaningful participation in community, activity, peer support)
Smith et al., 2008	The Brief Resilience Scale	Ability to bounce back from stress
Ungar et al., 2008	The Child and Youth Resilience Measure	Child and youth resilience across four domains (individual, relational, community, culture)
Wagnild & Young, 1993	The Resilience Scale	Individual resiliency- positive personal characteristic (personal competence, acceptance of self and life)
Windle et al., 2008	Psychological Resilience	Psychological resilience (self esteem, personal competence, interpersonal control)
Klohnen, 1996	Ego Resiliency	Components of ego-resiliency (confident optimism, productive and autonomous activity, interpersonal warmth and insight, skilled expressiveness)

Hjemdal et al., 2006	Resilience Scale for Adolescents	Protective resources (personal competence, social competence, structured style, family cohesion, social resources)
Bromley et al., 2006	Ego Resiliency 2	Ego resiliency (confident optimist, productive activity, insight and warmth, skilled expressiveness)

Note: List adapted from Windle, Bennet and Noyes, 2011.

In addition to resilience questionnaires, self-report measures assessing the level of stress-related changes and psychopathologies can be used to index resilience (Cohen, Kessler, & Gordon, 1997). Such self-report measures include perceived stress (Cohen, Kamarck, & Mermelstein, 1983) and measures of symptoms of anxiety (e.g., the State-Trait Anxiety Inventory; Spielberger, Gorssuch, Lushene, Vagg, & Jacobs, 1983) and depression (Patient Healthy Questionnaire; Spitzer, Kroenke, & Williams, 2001). Resilience is then conceptualized as the absence of such symptoms.

2.2.1.1 Floor and ceiling effects. Floor and ceiling effects are the inability of an instrument to capture distribution of a certain measurement below or above a certain level of the measured construct. A suggested indication of floor or ceiling effect is that more than 15% of the measured sample (presuming it is a sample that is intended for the scale) has the lowest or highest possible score (Windle et al., 2011). Of the mentioned resilience scales, a ceiling effect was reported for the California Healthy Kids Survey, all the remaining scales did not report either floor- or ceiling effects in the validation article (Sun & Stewart, 2007; Windle et al., 2011).

2.2.2 Longitudinal vs. cross-sectional measures of resilience. Prospective, multiple repeated measures designs of resilience have been recommended throughout the stress and resilience literature (e.g., Bonanno et al., 2011; Lepore, 1997). The use of measuring variables over several time points optimally proceeding, during and following a stressful event has even been suggested as the optimal way of capturing resilience (Bonanno et al., 2011). The advantage of quantifying resilience in this way (compared with a single resilience questionnaire) is that it enables comparison between baseline measures on variables with measures of the same variables after the stressful event. When measured over a longer time period (e.g., 1 year), it is possible to capture presumed distribution of resilience in a population, with some individuals showing resilience and other perhaps recovery or delayed stress responses. In addition, multiple repeated measurements allows for control of chronic stressors and other confounding factors (Lepore, 1997).

Cross sectional studies have their own advantages, among others it is advisable to conduct smaller experimental studies before embarking on more costly (both in time and economical means) longitudinal studies, to acquire some evidence that supports the research hypothesis that is to be investigated further (Lepore, 1997).

2.2.3 Predictors and markers of resilience. Given that resilience is likely to stem from many interacting factors, multi-factorial measurement might explain why certain individual stay resilient better than resiliency-questionnaires (Bonanno et al., 2011). Factors have been found to predict resilience, include (but are not limited to) demographical variables (e.g., Bonanno et al., 2011), personality variables (e.g., Bonnano, Rennicke, & Dekel, 2005; Carver, Scheier, & Segerstrom, 2010; Gupta & Bonanno, 2010), earlier experienced traumas (Breslau, Peterson, Poisson, Schutlz, & Lucia, 2004; Maguen, Lucenko, Reger, Gahm, Litz, & Seal, 2010), and experience of positive emotions (Fredrickson, 2001; Tugade & Fredrickson, 2004; Cohn, Fredrickson, Brown, Mikels & Conway, 2009). Several personality variables have been found to predict resilience. These factors are sometimes, but not always, related to factors incorporated in resiliency measurements. Personality traits and dispositions that are related with resilience are for instance optimism (Carver et al., 2010) and self-enhancement (Bonanno et al., 2005).

As this thesis focuses specifically on selective attention to emotional stimuli, this section focuses on predictors and markers of resilience that are related broadly with such a topic, leaving out other known predictors as for instance spirituality (e.g., Connor & Davidson, 2003). Below the predictors and markers of resilience that are relevant to this thesis are reviewed including the psychological factors optimism, high positive emotionality, suppression, and then socioeconomically factors and severity of the stressor. Finally, to achieve a holistic picture, a short introduction to genetic and neural markers of resilience is provided.

2.2.3.1 Optimism. Optimism is the mental approach to evaluation of the present situation and future situation with an optimal outcome in mind. The concept can relate to both a personality trait and so-called situational optimism (Carver et al., 2010). Higher optimism has been related to reduced distress after a wide range of stressors including for instance missile attacks (Zeidner & Hammer, 1992), care giving of a severely ill spouse (Given, Stommel, Given, Osuch, Kurtz, & Kurtz, 1993; Hooker, Monahan, Shifren, & Hutchinson, 1992; Shifren & Hooker, 1995), and progression of acquired immunodeficiency syndrome (AIDS) (Taylor, Kemeny, Aspinwall, Schneider, Rodriquez, & Herbert, 1992). It has been suggested that optimists cope in a different way than pessimist, and therefore experience less distress and better outcome in and after stressful events (Carver et al., 2010; Solberg Nes & Segerstrom, 2006). Optimists tend to see opportunities even when situations are difficult, and keep their focus on better outcome alternatives. This positive motivation has been suggested to create a tendency both to acknowledge and approach ways to achieve brighter situation both in the presence and in the future even when the going gets tough (Carver et al., 2010). An example of this can be found in women that underwent unsuccessful in vitro fertilization. Optimistic women reported that they had benefited from the difficult situation in a number of ways including becoming closer to their spouse (Litt, Tennen, Af Eck, & Klock, 1992). Further, optimists' use coping strategies in a different way than do pessimist in that they tend to use problem focused strategies in situations that are controllable (e.g., exams) and emotion focused strategies in uncontrollable situations (e.g., trauma) (Carver et al., 2010).

2.2.3.2 Positive emotions. The interest of the role of positive emotions in contributing to resilience is in part spurred by research from the laboratory of Barbara Fredrickson.

Fredrickson presented the "*broaden-and-build*" model stating that positive emotions have important evolutionary functions related to both enhanced well-being and a cognitive set characterized by broadening of attention and enhanced approach to novelty resulting in learning of new skills (Fredrickson, 1998, 2001, 2001). Cognitive processes related to a broader perspective must been seen in relation with earlier research showing that confrontation with a immediate threat is related to a narrowing of attention in direction of the threat stimuli (Carver, 2003). The Fredrickson lab has conducted considerate research on the role of positive emotions in resilience and found support for the "broaden and build" model.

For instance a study capturing daily mood ratings over a month found support for the broaden-and-build model, found positive mood to be the best predictor of resilience, unrelated to negative emotions (Cohn et al., 2009). Similar findings with positive mood predicting resilience have been found in several studies (e.g., Fredrickson & Joiner, 2002; Ong et al., 2006). In addition, positive emotions in bereaved and grieving individuals have been found to predict better adjustment later on, also independent on the amount of negative feelings at the time of grief (Bonanno & Keltner, 1997; Bonnano et al., 2005).

An additional finding that might be related to resilience is Gottmann's research into marriage success and happiness, where a ratio of 5:1 for positive vs. negative emotions was suggested to indicate a good outcome of the marriage (Gottman, 1994). In line with such research, it has been suggested that the positive and negative emotion ratio similarly need to be over a certain threshold to predict resilience (Fredrickson, 2013). More frequent positive emotion predict better resilience outcome, at least until an undefined upper limit (Fredrickson, 2013). Extremely intense positive emotions, on the other hand, has been found to predict worse outcome in different circumstances, for instance in employer creativity (Fredrickson, 2013). Based on the mentioned findings, the impact of positive emotion on resilience might be U-shaped. Low frequency of positive emotion might be related to less resilient outcome, then higher frequency might be increasingly related to higher resilience, but at some upper limit more positive emotion might be related to lower resilience. The reason for the U-shaped relationship between positive emotion and resilience has been suggested to be that the interplay between negative and positive emotions is crucial for resilience. Lack of positive emotion, but also lack of negative emotion, leads to worse resilience outcomes (Fredrickson, 2013).

2.2.3.3 Suppression of cognition and emotion. Positive emotions might be interpreted as suppression of negativity, especially if positive stimuli and emotions are habitually or consciously sought out to regulate emotion to more positivity.

However, it has been suggested that suppression of traumatic memories, including avoiding “making meaning” of a stressful or traumatic event might constitute an important coping strategy in resilient individuals. Early studies of holocaust survivors showed that suppression of memories of the holocaust was related to better health, work and family situations (Kaminer & Lavie, 1991, 1993). Recent years have seen several finding supporting this early result, with less meaning making in resilient individuals (Westphal & Bonanno, 2007), and low frequency of individuals actually seeking to make meaning after a stressful event (Bonanno, 2013; Davis, Wortman, Lehman, & Silver, 2000).

At first sight, these are quite controversial findings, suggesting that it’s might be better to “forget and move on” (if you can) and it has been questioned if the individual and society as a whole can acquire knowledge from a repressed and “forgotten” event. However, suppression might be an important strategy in response to specific external an internal stimuli, and not as a mean of denying an event. Based on a literature review Park (2010) suggested that it is important to distinguish between violations of global beliefs, which are related to self and the world, and situational beliefs, which are appraisals about a specific event or period that one has been through. In the case of violations of global beliefs, it might be an adaptive strategy to focus on making meaning and changing appraisals (Park, 2010). On the other side, focusing on meaning making about a specific event that one has been through, might instead be related to worse outcomes in terms of adaptation to stress (e.g., higher depression) (Park, 2010; Sales, Merrill, & Fivush, 2013).

2.2.3.4 Emotional reactivity. More negative affect and affective reactivity has been found to predict worse functioning as long as 10 years after the measurement of reactivity (Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013). A recent finding showed that individual that react with more negative affect, even to minor stressors, are more likely to show adverse mental health development (i.e., more psychopathology) (Charles et al., 2013). Other findings include that those individuals reacting with more negative emotions show more depressive symptomatic in response to study stress (ONeill, Cohen, Tolpin, & Gunther, 2004; Parrish, Cohen, & Laurenceau, 2011).

2.2.3.5 Socioeconomic profile of resilience. A resilient profile includes being male, highly educated and have older age (Bonanno et al., 2011). In addition, it is by now well known that economical factors play an important role in adaptation to stress. Availability of resources after a trauma has been repeatedly related to more resilient responding (e.g., Bonanno et al., 2011; Brewin, Dalgleish, & Joseph, 1996; Norris et al., 2002). Social resources have been found to predict resilience as well, with higher social support being beneficial for resilience (Bonanno et al., 2012; Hobfoll, 2002).

2.2.3.6 Severity and timing of the traumatic or stressful event. Research about resilience includes a wide range of stressors, from mild stress (e.g., exam stress), over highly stressful events (e.g., bereavement) to severe trauma (e.g., genocide). The severity, frequency and chronicity of stressors or traumata might require different type of responses and result in different impacts on psychological and physiological functioning (McEwen, 2008). The severity and continuity of the stressor has repeatedly been related to the percent of individuals that develop stress-related disorders after the trauma (Bonanno et al., 2006: Bonanno et al., 2011). As an example, 55.6% percent of individuals witnessing 9-11 attack on the twin towers in New York were resilient after six months, compared with 32.8% of those injured by the attack (Bonanno et al., 2006). Such numbers point to one important fact: the severity of the stressor counts, with more severe stress leading to more stress symptomatic across the population (MacEwen, 2008).

The timing of the trauma might impact how severe the influence of the stressor is on the individual, as certain times in the development (i.e., early childhood) are more sensitive (Karatoreos & McEwen, 2009). It has repeatedly been found that severe stressors in childhood impacts resilience later in life, with worse resilience outcome over the whole population (e.g, Kyle & Pichard, 2006). A throughout introduction to effects of timing of the stressful event is beyond the scope of this thesis (but see e.g., Karatoreos & McEwen, 2009).

2.2.3.7 Genetic markers of resilience. Genes play a part in how vulnerable we are to stress, and several genes have been related to stress responses and resilience (Charney & Southwick, 2012). Although a complete review of genetic influence on resilience is beyond the scope of this thesis, a few findings will be provided. For instance, the norepineprhrine response might be associated with variations in the neuropeptide Y gene, and such variations are related to individual differences in stress responses. For instance, individual with a gene variation related to low expression of neuropeptide Y, have been found to react with increased anxiety and amygdale response when presented to threatening stimuli (Charney & Southwick, 2012; Zhou, Zhu, Hariri, Enoch, Scott, Sinha, et al., 2008). Additionally, a variation of the alpha-2 adrenoreceptor gene (i.e., alpha-2cDEl322-325-AR) is associated with increased baseline levels of norepinephrine, larger stress-related increase of norepinephrine, as well as slower return to baseline levels after the end of the stressor (Neumeister, Charney, Belfer, Geraci, Holmes, Sharabi, et al., 2005). Another gene that might affect stress responses over its actions on the sympathic nervous system (SNS) is variation in the serotonin transporter linked polymorphic region gene (5-HTTLPR). Being a carrier of the short allele of this gene that codes for low expression of serotonin is associated with less resilient responses to stressors (e.g., Munafo, Brown, & Hariri, 2008).

2.2.3.8 Neural markers of resilience. It has been suggested that preserved responses in those areas involved in cognitive and attentional control as well as reward processing when confronted with challenging is characteristic of resilient individuals.

2.2.3.8.1 Prefrontal Regions and Attentional Control

The prefrontal cortex (PFC) is involved in all voluntary actions, including direction of attention (Palermo & Rhodes, 2007). It has been proposed that the PFC is involved in emotion regulation (including positive emotions) (Palermo & Rhodes, 2007). In line with this suggestion, higher activation of the PFC is related to higher activation of the amygdale; possibly indicating increased efforts to regulate emotion (Palermo & Rhodes, 2007).

Attentional control enable modulation of selective attention, for instance away from negative and toward positive stimuli. More activity is found in the PFC following successful training to direct attention toward a specific type of stimuli (Monk, 2008). For instance, individuals with a generalized anxiety disorder (GAD), who participated in a attentional retraining to learn how to focus away from threat stimuli, showed larger activation in PFC in response to threat stimuli after compared with before the training (Monk, 2008).

Further, it has been found that the prefrontal regulation related to reward circuits is reduced following stressors (Ossewaarde, Qin, Van Marle, van Wingen, Fernandez, & Hermans, 2010). Such reduction might be related to for instance higher probability to give in to short-time rewards in stressful situations (e.g., eating sweets) (Ossewaarde et al., 2010), but also to less ability to regulate attention away from negative stimuli (Troy & Mauss, 2013). It might thus be that preserved prefrontal regulation of attention and emotions constitute an important component of stress resilience. Chronic stress has been found to induce structural changes in the prefrontal cortex in human subjects (McEwen, 2012). These changes have been suggested to be related with reduced cognitive flexibility dependent on prefrontal activation (Liston, McEwen, & Casey, 2009).

2.2.3.8.2 Reward Circuit of the Brain

The reward circuits of the brain, including the medial PFC, the anterior cingulated cortex (ACC) and nucleus accumbens, are activated in response to pleasant stimuli, and in most individuals the activation is reduced in response to unpleasant or less pleasant activities or stimuli (e.g., Hare, Tottenham, Davidson, Glover, & Casey, 2005; Sharot, Riccardi, Raio, & Phelps, 2007). For instance activities and stimuli related to food, sex, and positive social behavior have been found to elicit responses in this circuit (van Marle, Hermans, Qin, & Fernandez, 2009). The actions of the reward circuit are generally related to mesolimbic dopaminergic activities in the brain (e.g., Nestler & Carlezon, 2006). Interestingly, it has been suggested that the broadening of attention associated with the experience of positive emotions is related to an increase of dopamine levels in the reward circuits of the brain (Ashby, Kim, Kumar, Lang, & Lozano, 1999; Charney & Southwick, 2012).

Charney & Southwick (2012) proposes that stress reduce responses to pleasurable activities and stimuli in the reward circuits of the brain, but that highly resilient individuals are characterized by high activity in reward circuits regardless of if they are confronted with pleasant or unpleasant stimuli. For instance, in an imaging study with Special Forces soldiers, (especially picked out and trained to be resilient) incorporating both loss and win conditions (i.e., money), the activity in ACC was not reduced in the Special Forces soldiers in response to loss, but healthy control subjects showed a reduction of activity to such stimuli (Vythilingham, Nelson, Scaramozza, Waldeck, Haylett, Southwick et al., 2008).

Taken together, preserved activation of prefrontal and reward circuits when facing unpleasant situations and stimuli might be indicative of resilience.

Chapter 3 – Selective attention

Clinical cognitive-behavioral models of psychopathology strongly emphasize cognition as influencing stress reactions and disorders (Beck, 1978). Cognition is a broad concept including all processes involved in processing sensory information. An essential part of cognition is attention. An important characteristic of attention is that it includes some stimuli at the cost of other; a phenomenon described as selective attention (Cohen, 1993). The limited capacity of the attentional system leads to that the direction of attention strongly influences our experiences of different situations (Desimone & Duncan, 1995; Duncan, 2006). Consider the following through experiment suggested by Kenneth H. Heilman (1993, In Cohen, 1993, p. vii):

"*As you read this, you are probably unaware of how your left foot feels in your shoe. Although your brain was receiving sensory input from this foot, you were not aware of your foot because you were reading and not attending to it. However, this discussion led you to move your attention to your left foot and to become aware of it*".

Research about selective attention and its impact on emotion and behavior rely on the assumption that increased selective attention to stimuli result in increased reaction to these stimuli (Cohen et al., 1997). The stimuli thus functions as a "trigger" of emotions and behaviors (Beevers & Carver, 2003; Nisbett & Ross, 1980; Phelps, Ling, & Carrasco, 2006).

A well-known example from the clinical realm, are anxious individuals that exhibit *biased attention* to threat stimuli (Bar-Haim et al., 2007). This means that anxious individual detect threat stimuli easily, even when the threat is not necessarily relevant and they might react to the threat signals with increased anxiety and maladaptive behavioral patterns such as exaggerated avoidance (e.g., Bar-Haim et al., 2007). In addition, anxious individuals exhibit deficits in regulation of selective attention such that they are prone to be distracted by negative stimuli, i.e. they exhibit deficits in *affective control* (Bishop, 2009). The lack of attentional control increases the inability to regulate the threat vigilance (Bishop, 2009).

Both biased attention and affective control influence where selective attention is directed. Biased attention is brought about by increased stimuli representation in sensory cortices, resulting in a comparative advantage for stimuli matching such representations in the attentional process (Desimone & Duncan, 1995; Duncan, 2006). Affective control, on the other hand, is the ability to selectively focus attention to and away from emotional stimuli, thus overriding the influence of distracting irrelevant stimuli (Egner, 2007). Attentional and affective control is exhibited in accordance with the level of conflict in the environment, with higher conflict leading to higher exhibition of control (Egner, 2007). Therefore recent research often investigates attentional control under the premise of conflict adaption, which takes variations in conflict (e.g., variations in congruency in both previous and current trials in the Stroop task) into account. Biased attention and attentional control are distinct aspects of selective attention, but have been found to mediate the impact of each other (Botvinick, Braver, Barch, Carter, & Cohen, 2001). The studies presented in this thesis concerns biased attention (study 1) and affective control (study 2 and 3) under the premise of conflict adaption in relation to the expression of stress resilience in healthy individuals.

For this reasons, this chapter introduces models of biased attention (3.1), models of biased attention in psychopathology (3.2) and models relevant for attentional and affective control under the premise of conflict adaptation (3.3). Due to that some of the assumptions of this thesis relies on neuropsychological models next follows an introduction to the neural basis of selective attention is provided (3.4),. Thereafter, an introduction to measurements of selective attention is given, (3.5). Finally overviews of typical findings regarding biased attention to emotional stimuli (3.6) as well as affective control (3.7) in healthy and clinical populations are provided.

3.1. Models of Biased Attention

The predominant model in AB research, the biased competition model (Duncan & Desimone, 1996; Duncan, 2006), suggests that representations of stimuli compete for limited attentional capacities[2], leading to the selection of certain stimuli. Representations give rise to biased attention, through pre-activation of the neurons wired to that representation (these can be very specific, for instance you have specific neurons reacting to your mother), which increases sensitivity to certain stimuli (Duncan, 2006). As a consequence of the changing content of the working memory, attention biases are contextual and flexible (Duncan, 2006). Since there are limits to processing capacity only a slight part of the environment will interact with our sensual nerve ends. We selectively attend some information; a sort of "filter" admits selective attention (Broadbent, 1958). Or, as Duncan (2006) puts it, "*the filter implies that competitive winners and losers are determined by task context*" (p. 10).

Biases can have a bottom-up or top-down character. Top-down biases are results of for instance previous learning or situational framework, while bottom-up biases are seen in response to activation of specific features of evolutionary salient stimuli and certain other stimuli properties such as familiarity or novelty (Duncan, 2006; Ohman & Mineka, 2001; Todd et al., 2012).

When attention is biased to a specific type of stimuli with some consistency, we exhibit an *attentional bias* (AB) to this category of stimuli (e.g., Duncan, 2006). For instance, if we exhibit a bias toward stimuli of an emotionally positive valence, we are said to have an AB toward positive stimuli.

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[2] Working memory and attentional resources are limited, and therefore an individual capacity to attend to stimuli is dependent on priorities as available attentional resources can be exhausted. Exhaustion of attentional resources and working memory capacity are related to decrease in performance (Mathews & Mackintosch, 1998; Yiend, 2012).

ABs thus indicates stronger selective attention to certain aspects of the available stimuli in our surroundings (Duncan, 2006). Thereby ABs modifies the “reality construction” that shapes our understanding of different situations.

Further, ABs are typically related to responses to the biased stimuli (Cohen et al., 1997). Emotions and behaviors are thus elicited as a response to the stimuli that function as a “trigger” (Beevers & Carver, 2003; Nisbett & Ross, 1980; Phelps et al., 2006).

Attentional biases to psychopathological relevant stimuli are commonly found for instance in anxiety (i.e., threat stimuli) and depression (i.e., self-related sad stimuli) (e.g., Bar-Haim et al., 2007; Yiend, 2010).

Although considerable literature exists on negative biased attention, research about selective attention to stimuli of positive valence is still in its cradle (Herring, Burleson, Roberts, & Devine, 2011; Yiend, 2010). Attention to positive stimuli might elicit positive emotions like joy, surprise, and amusement. Such feelings are in turn related to approach behavior. The experience of positive emotions in general are of importance for activating reward-seeking behavior that might lead to for instance finding a partner, social support, as well as food and other resources (Matsumoto & Ekman, 2010).

Although sufficient research is lacking (Yiend, 2010), preliminary result point to that subjects specifically picked out to have low vulnerability to psychopathology (e.g., scoring low on anxiety or depression symptomatic, lacking family history of psychopathology, carriers of specific protective genes) might show AB to positive stimuli (e.g., Frewen et al., 2008; Joorman et al., 2007).

The main models of ABs toward emotional stimuli in the research literature are reviewed in this section.

3.1.1 Cognitive effort and ease. Kahneman (2012) has proposed that the mind works in two different modes or processes, namely (1) a cognitive system of cognitive ease and (2) a system of cognitive effort. These two systems have different functions, with the cognitive-ease-system activated during tasks that require little effort, actions and thoughts that "just feel right", while the cognitive-effort-system is associated with effortful analysis and going against intuition. Kahneman (2012) suggest that we use cognitive-ease-system in circumstances that are familiar, clearly presented, primed and that we experience in a good mood. When we use this system, our thoughts are experienced as easy and they feel true, familiar, effortless and good. We use the cognitive-effort-system when circumstances feel unfamiliar, unclear, and that we experience in a bad mood. Such circumstances are likely to be perceived as difficult and uneasy, unfamiliar, false, needing effort or wrong (Kahneman, 2012).

It has been found that when we are happy we are better at intuitive, associative task, while being in a bad mood renders us unable to perform such tasks (Kahneman, 2012). Good mood thus goes together with more cognitive ease, and increased reliance on intuition. In a good mood we are more creative, and intuitive but also more prone to be deceived by superficial solutions and thoughts. Negative moods such as anxiety and sadness go together with a more analytic cognitive style and in such moods we are less likely to make logical errors (Kahneman, 2012). We also seem to get in a good mood by tasks that produce cognitive ease. Kahneman (2012, p. 69) brings the following example. "*Briefly consider the row triads of words:*

sleep mail switch

salt deep foam

"*You could not know it, of course, but measurement of electrical activity in the muscles of your face would probably have shown a slight smile when you read the second triad, which is coherent (sea is the solution)".*

Attentional biases related with mood might thus lead to "pattern of deviation in thought and emotion" occurring in perception and judgment in certain situations (Tversky & Kahneman, 1992). Not only individual afflicted with psychopathology exhibit distortions of cognition, but all of us are prone to exhibit a range of ABs for characteristics such as familiarity and current goals (Kahneman, 2012; Tversky & Kahneman, 1992).

An example of an AB that most of us exhibit to some degree is the confirmation bias (Wason, 1960). This bias leads most individuals to favor information that confirms their preconceptions or hypothesis. We seek out information that confirms our view of the current 0conditions and we neglect contradictory information (Kahneman, 2012; Tversky & Kahneman, 1992). The confirmation bias can be partly explained with that it is cost-effective in terms of cognitive resources. Our attentional capacity is limited, and perceiving the environment according to our preconceptions results in reduced ambiguity and therefore less cognitive resources are needed to "make sense" of a situation. However, cognitive ease is not an indication of that we perceive a situation realistically, it is rather an indication of reduced analytic engagement with a specific situation (Kahneman, 2012).

Figure 4. Illustration of Confirmation Bias

Note: Illustration of the confirmation bias made by Heath Hinegardner.

3.1.2 Biased competition model. The predominant model in AB research, the biased competition model (Duncan & Desimone, 1996; Duncan, 2006), suggests that representations of stimuli compete for limited attentional capacities over many inter-joined neural systems, leading to the selection of certain stimuli. Single cell recordings have shown suppression of non-relevant stimuli that takes place about 100-200 ms after stimuli onset (Duncan, 2006). Representations of stimuli can be of bottom-up or top-down character. Top-down biases are results of for instance previous learning or situational framework, while bottom-up biases are seen to evolutionary salient stimuli that and certain other stimuli properties such as familiarity or novelty. These representations result in biased attention, and direct the attention toward specific stimuli properties. For instance, if a target is primed before trial onset, activity is initiated already before the trial (small, sustained activity in the cells that have to respond to the stimuli) "*potentially the pre-activation could produce a significant competitive advantage for those cells*" (Duncan, 2006, p. 8). According to the biased competition model, as well as extensive experimental evidence, biases can only be detected in experimental paradigms creating competition for attentional resources (Duncan, 2006). For instance, biases to emotional (vs. neutral) stimuli generally are only seen in paradigms where these stimuli are presented together (e.g., Calvo, Nummenmaa, & Hyona, 2008; MacLeod, Mathews, & Tata, 1996).

3.2 Models of biased attention in psychopathology

Several models have been presented to explain biased attention in specific psychopathologies. Most of these models concern anxiety and depression. A choice of these models is presented below.

3.2.1 Negative dysfunctional schemata model. Beck (1976) suggested that negative dysfunctional schemata color attentional processes in individuals afflicted by psychopathology. This model might still be useful in clinical settings, and is sometimes referred to in research literature. However, a recent meta-review (Yiend, 2010) suggested that this model no longer could be claimed to accurately describe experimental findings. The negative dysfunctional schemata view predicts that the influence of schemata will be similar over all psychopathologies and all dysfunctional schemata, but this has been shown not to be the case (Yiend, 2010).

3.2.2 Two-stage theory. The two-stage theory (William, Watts, MacLeod, & Mathews, 1988) has helped explain a crucial difference in biases found in anxious and depressed populations. ABs in anxious populations have been found predominantly after short presentation times, while biases in depressed populations appear after longer presentation times (e.g., Peckham et al., 2010). In contrast with earlier models of biased attention in psychopathological groups, the two-stage theory separates biases arising from distortions in priming and elaboration. Priming stands for the activation of representations of stimuli that makes such stimuli more accessible, and according to the two-stage theory anxious individuals have constantly active representations of threat stimuli, that make such stimuli more accessible at all times for such individuals (Williams et al., 1997). Elaboration stands for later processing, such as retrieval that involves activation of connections of representations. For instance, the mood-congruent ABs to sad stimuli in depression are thought to be biases of elaboration rather than in priming (Williams et al., 1997).

The two-stage theory proposed that traits, like trait resilience for instance, impact the attentional process through modifying resource allocation resources so that a trait – congruent processing of stimuli is increased. Trait resilience would therefore increase processing of resilience-promoting stimuli. State mood, on the other hand, modifies affective decision mechanisms, which evaluates the emotional valence of stimuli. For instance, higher positive mood would lead to evaluation of positive stimuli as more intensively positive than when in a less positive mood.

3.2.3 Cognitive-motivational analysis. The cognitive-motivational analysis (Mogg & Bradley, 1998) is divided in a "valence evaluation system" (VES) and a "goal engagement system" (GES). In this system, the GES is a default state, which keeps the individual on track to achieve its goal. GES is predominantly directed toward positive, rewarding stimuli that signalize goal attainment. The attentional tuning from the GES system is only interrupted when a stimuli is intensive enough (for instance due to its evolutionary salience) to set off the VES. The importance difference from the two-stage theory is that trait and state (as well as additional factors such as context) impacts the sensitivity of the VES system. Thus, according to the cognitive-motivational analysis dysfunctional ABs are found in the extremes of a sliding scale from very sensitive to very insensitive in terms of VES response.

3.3 Attentional and affective control under conflict adaptation

Attentional control is the ability to direct attention to and from stimuli, including the ability to stay focused on task relevant stimuli and ignore distracters (Egner, 2007; Gray et al., 2009). There is ample evidence from imaging studies showing that control to neutral and emotional stimuli is processed in overlapping but distinct neural circuits (Etkin, Egner, & Kalisch, 2011; Etkin, Egner, Peraza, Kandel, & Hirsch, 2005). It might therefore be wise to divide attentional (i.e., to neutral stimuli) and affective control, i.e. attentional control to emotional stimuli (e.g., Egner, 2007). In the presence of emotional distracters, the individual level of affective control influences how well the individual can discharge such distracters and stay on task.

However, both attentional and affective control can be fitted under a larger umbrella term of „cognitive control“. Cognitive control is the ability to adapt behavior to reach an internal goal. It involves a range of different abilities such as working memory ability to keep current goals active and avoid distracters, producing and monitoring task strategy, and flexibly adapt behavior to feedback during the course of goal pursuit (e.g., Goeschke, 2014).

Attentional control is exhibited in accordance with the level of conflict (Botvinick et al., 2001). This means that attentional control increases when more control is needed, as in situations with an increasing level of stimuli conflict. This perspective has been put forth in a recent model; the cognitive control loop model (Botvinick et al., 2001). This thesis concerns affective control within the premises of conflict adaption, and this section will therefore specifically cover models concerned with attentional control within the framework of conflict adaptation, including the conflicting models of control loop and feature integration.

As attentional control is used interchangeable for control of both neutral and emotional stimuli in the relevant models the introductions fuses these concept. Differences in processing of neutral and emotional stimuli in relation with control are further discussed under neutral models of selective attention.

In the following section the main model of attentional control under conflict adaptation, the cognitive control loop model, is presented. Thereafter, an alternative model, the feature integration theory, is outlined, and finally a discussion of conflict adaptation and feature integration might influence measures of congruency sequence effects is provided.

3.3.1 The conflict control loop. The conflict control loop model concerns the ability of selective attention to flexibly adapt to variation in the level of conflict in the surroundings through increasing or decreasing the exhibition of attentional control (Botvinick et al., 2001). The main asset of this model is the focus on how "*intervention of control processes are brought about*" (Botvinick et al., 2001; p. 624) in contrast to how attentional control influences different parameters (Botvinick et al., 2001). Conflict resolution is mediated by the immediate presence of conflict in preceding trials. For instance, performance to incongruent trails is enhanced if the previous trial was incongruent as well. This effect is called the congruency sequence effect. In the conflict control model, conflict is detected by a conflict monitor system that in turns increases cognitive conflict efforts leading to a higher level of exhibited control. Imaging studies contrasting low and high conflict trials have supported this division (i.e., the dorsal anterior cingulated cortex is involved in conflict monitoring and the lateral prefrontal cortex in conflict resolution) (Etkin et al., 2011; Etkin et al., 2005).

According to this model, attentional control is recruited to a higher degree when more attentional control is needed, such as when task difficulty increases. Supportive evidence come for instance from studies with the Stroop task showing that interference is larger for the initial trials in each block when using block designs (e.g., Botvinick et al., 2001). Further, it seems that adjustment of the level of attentional control occur for instance in response to errors, as performance tend to improve thereafter (e.g., Botvinick et al., 2001). Building on such findings, the model of conflict monitoring suggests that a "*regulative dimension*" is essential for the exhibition of attentional control (Botvinick et al., 2001). Botvinick and colleagues (2001) refer to this dimension as conflict monitoring.

Conflict monitoring ensures that the level of attentional control is adapted to the immediate task need and is thus essential for an adaptive exhibition of attentional control. It is suggested that the conflict monitoring system is involved in an ongoing evaluation of the level of conflict in the surroundings and constantly passes this information to centers that are involved in attentional control. Attentional control is thus governed by an ongoing feedback system involving evaluation that aids conflict monitoring and exhibition of attentional control (Botvinick et al., 2001).

The conflict-monitoring model has received strong support from imaging, single unit and event-related studies. Attentional control is commonly related with the ACC and this area has also been found to respond in the majority of conflict studies (Botvinick et al., 2001). For instance, the ACC is activated when responses has to be overrode, as in the Stroop task, where early studies showed higher ACC activation is found in incongruent compared with congruent trials (Pardo, Pardo, Janer, & Raichle, 1990).

Conflict adaptation has been found in Stroop task studies when trial-type frequency effects are analyzed. This effect shows that interference is lower (i.e., the difference in RT from congruent trials) when incongruent trails are more frequent (Botvinick et al., 2001). Botvinick and colleagues (2001) interprets this effect as evidence that attentional control resources are allocated to changes in conflict, such as that attentional control is higher in the current trial if it precedes an incongruent trial. The findings from studies of conflict monitoring have important implications for the measurement of individual differences in attentional control, as it indicates that the level of conflict should be taken into account when measuring individual differences in attentional control.

3.3.2 The feature integration theory. Treisman and Galde (1980) suggested that details of visual features (e.g., color, orientation, brightness) are processed in a fast parallel and automatic manner while more complex stimuli require slower serial searches. More complex processing includes “conjunctions of features”, which means that complex stimuli are put together by identifying several characteristics in following visual searches (Treisman & Galde, 1980). The features of an object are first examined in different, parallel feature maps, and the integration takes place later through spatial attention and top-down mechanisms (e.g., Zmigrod & Hommel, 2012). Further, the feature integration theory assumes that integrated information about an object is saved for a time in so called object files (Tversky & Kahneman, 1992). For instance, if an object appears in a particular spatial location, this particular feature is saved (together with other information) in the object file. Consequences can be seen for instance as shorter RT to objects presented in the same spatial location repeatedly. This model also has support from research showing that detection of certain characteristics, such as color, is not dependent on the number of distracters, while the search time is dependent on number of distracters for complex stimuli (Yiend, 2010). Neuroimaging studies have confirmed that repeated presentation of a feature activates the neural representation of that feature together with the features that were presented together with it in earlier trials (Keize, Nieuwenhuis, Colzato, Theeuwisse, Rombouts, & Hommel, 2008; Zmigrod & Hommel, 2012)

Different suggestions have been made to explain how feature integration effects arise. An early account suggested neural convergence such that combination of features (e.g., a certain color and direction) would activate a network of neurons (e.g., Barlow, 1972; Zmigrod & Hommel, 2012). Later suggestions include temporal synchrony, which states that neurons related to a specific event (object event) fire in a common rhythm across the brain (e.g., Engel & Singer, 2001). The latter model has been supported by substantial neural evidence (for an overview see e.g., Zmigrod & Hommel, 2012). The current stand is that both neural convergence and synchrony influence feature integration, but that these mechanisms are relatively unaffected by each other (Zmigrod & Hommel, 2012). Zmigrod & Hommel (2012) writes, in an illustrative example, that neural convergence might represent learning effects, such as the well-known feature conjunction of yellow color and a banana. Such “over learned” feature conjunction lead to faster processing of this particular feature combination. However, to allow for flexibility of feature integration, other related combinations must be possible even if less likely. In such cases, synchrony might play a more prominent role, activated along with more established feature conjunctions (Zmigrod & Hommel, 2012).

3.3.3 Integration of attentional control and feature integration. It has been suggested that feature integration is influenced by intentional attention (e.g., Hommel, 1998; 2007). In line with such suggestions, it has been found that feature integration bindings (i.e., bindings between different features in an object file) are stronger if certain features are task relevant. However, this holds true only for some feature types including shape and spatial location[x], while task relevance of other features, such as color, leads to weaker bindings (Hommel et al., 2004). Recent evidence has supported that attentional control affects feature integration, but suggests that this such influence might be specified to certain aspects of feature integration, such as retrieval of recent bindings (Hommel, Memelink, Zmigrod, & Colzato, 2013). Further, in a recent paper, Hommel et al. (2013) suggests that attentional control (i.e., here: task relevant attentional control) results in priming of task relevant features and make such features efficient cues of retrieval.

3.4 Neural foundation of visual selective attention

Theories of selective attention, including theories of biased attention and affective control, are often grounded in research stemming from imaging studies and other studies including neural measures (i.e., single units, event related studies). Thus, even though the studies presented in this thesis do not include such measures, a general understanding of the neural basis of selective attention is essential to interpret the results. Therefore a brief introduction to the neural foundation of selective attention is provided in this section, starting with a an introduction to how sensory stimuli are transferred to and handled in visual cortex (3.3.1), followed by the neural basis of biased attention (3.3.2) and finally routes for attentional and affective control are reviewed (3.3.3). This section is not exhaustive, but rather intended at giving a general introduction to the research underlying the studies presented in this thesis.

3.4.1 From visual stimuli to visual perception. Visual attention is dependent on different parts of the eye facilities. Visual perception is created by light falling on the retina, a thick layer of cells at the back of the eye. From the retina, visual information is transferred through the optic nerve from where it is forwarded to the optic chiasm. At the optic chiasm there is a partial crossing of axons (so that information from the retina of both eyes are transferred together thereafter). The optic tract is attached to the optic chiasm and wraps around the midbrain and reaches the lateral geniculate nucleus (LGN) where all axons synapse. Thereafter the axons form fan-like matter throughout the white matter before it finally reaches the primary visual cortex in the back of the brain (e.g., Dragoi, 2013). Damage to any part of the optic pathway causes blindness in the affected individual, although some visual signals still are processed outside of reach of consciousness (i.e., blind vision[3]) (e.g., Dragoi, 2013).

3.4.1.1 Primary and secondary visual cortex. The primary visual cortex (V1/Brodmanns area 17), or striate cortex, is located in the posterior occipital lobe of the brain. Neurons in the LGN projects to V1, that in turn projects further to the secondary visual cortex (V2/ Brodmann´s areas 18 and 19). V1 and V2 are both organized in layers, with substantial inter layer projection as well as projections from V1 to V2. Neurons in V1 and V2 are divided in simple and complex cells, depending on if their actions are simple or complex (Huber & Wiesel, 1959, 1962). Both simple and complex cells respond to incoming light that matches a certain position (common in simple cells), shapes or orientation (simple and complex cells), direction (complex cells) and in some cases color (i.e., in blobs). The neurons of the secondary visual cortex are more diverse then in V1, and additional complex processes are thought to take place in V2 such as the activity of so called hyper-complex cells, that for instance react to lines of a specific length (e.g., Dragoi, 2013). These cells are hyper-complex because they use information from several less complex cells and form abstractions based on the addition of information. The hyper-complex cells have access to information from other simpler cells through joint axons on a single neuron (e.g., Dragoi, 2013).

3.4.1.2 Visual association cortex (V3, V4, V5). Projections in the visual cortex follow a hierarchical pathway from V1, over V2 and further via the other visual cortexes V3, V4 and V5. Less is known about the function of neurons in V3, but neurons here are involved in orientation, motion and depth detection (e.g., Dragoi, 2013). V4 has many neurons that are color sensitive, and is therefore thought to be involved in color perception. In addition, neurons here detect for instance orientation and other aspects of spatial visual perception (e.g., Dragoi, 2013). The middle temporal area (MT), or V5, has neurons involved in motion detection (e.g., Dragoi, 2013).

3.4.1.3 Projections from V1 and V2. Cells from V1 and V2 project into two major cortical systems, called the dorsal and ventral pathway. For instance, layer 4B in V1 projects to V2, from where projection goes further to V3 and MT in a *magnocellular* pathway (dorsal pathway; e.g., Dragoi, 2013). Other cells in V2 get projections from blob and inter-blobs of regions 3 and 4 of V1, and projections are then sent further to V4 as part of the *parvocellular* pathway (ventral pathway; e.g., Dragoi, 2013). The division of these two cortical systems might be somewhat arbitrary, as they are partly overlapping (e.g., Dragoi, 2013). However, schematically the dorsal pathway is thought to feed the parietal lobe that is implicated in locating objects (e.g., Dragoi, 2013), while the ventral pathway feed mainly to temporal lobes implicated in recognition of objects (e.g., Dragoi, 2013).

3.4.2. Neural circuits of biased attention. Simplified, two main routes for biased attention can be singled out; (i) a rapid threat detection amygdala based route that further amplifies sensitivity in visual cortices, leading to a non-specific attentional preparedness (e.g., van Marle et al., 2009), and (ii) a route for top-down biased attention over dorsolateral pathways from the posterior parietal cortex to dorsal prefrontal cortex (e.g., Hollander & Gallagher, 2004). This second pathway is thought to be involved in keeping working memory au pair with current goals and tasks (Palermo & Rhodes, 2007).

Rapid threat orientation results in a general preparedness, and this state are associated with a likelihood of false positives (i.e., we sometimes detect threats where there are none) (van Marle et al., 2009). The neurophysiologic response to threat of the amygdale, have been found to further increase sensitivity of visual pathways and face processing areas (i.e., fusiform gyrus), inducing a highly sensitive but non-specific attentional preparedness (van Marle et al., 2009). It has been argued that early threat detection and detection of emotional conflict are both activates bottom-up processes (Etkin et al., 2011; van Marle et al., 2009).

The dorsolateral pathway for top-down biased attention is not related to emotional valence in first hand, but to the match of processed stimuli features with representations activated by the current task (Banish et al., 2001). Such top-down biased attention for emotional stimuli is likely to involve integration of emotional and cognitive aspects, processes that have been suggested to involve the ACC and lateral prefrontal areas (Gray, Braver, & Raichle, 2002; Palermo & Rhodes, 2007).

The processing of face stimuli provides a relevant example of how biased attention functions in a neural dimension. Face stimuli are evolutionary salient stimuli that are likely to evoke both bottom-up and top-down biases (Johnson, Dziurawiec, Ellis, & Morton, 1991; Rousselet, Mace, & Farbe-Thorpe, 2003). Face processing involves several brain regions, including the retina, the LGN, the fusiform gyrus (FG), the amygdale, the ACC and the ventromedial prefrontal cortex (Palermo & Rhodes, 2007). Within this large system, several sub-circuits exist that are thought to be involved in specific aspects of visual face processing.

Intensively threatening disgusted or fearful expressions are processed through a very rapid detection circuit, that is activated in response to specific visual characteristics (e.g., shape of eyebrows; Lundquist, Esteves, & Ohman, 1999) (Ohman & Mineka, 2001). An alternative route for rapid threat detection that includes a subcortical pathway to the amygdale, over the superior colliculus and pulvinar thalamus has been suggested (LeDoux, 2000; Phelps & Ledoux, 2005; Vuilleumier, 2005). For less salient face stimuli, it seems that the amygdale "evaluates" the relevance of the stimuli, and modulates visual attention through feedback systems over the visual cortex (Palermo & Rhodes, 2007).

Amygdale activation to both unattended and attended threat stimuli have been found in imaging studies, although the response is milder when the stimulus is unattended (Holme, Vuilleumier, & Eimer, 2003; McCarthy, 2000). For happy face stimuli in contrast, responses of the amygdale is seen only when the stimuli is attended to (Palermo & Rhodes, 2007; Williams, Moss, Bradshaw, & Mattingley, 2005).

Biased attention to face stimuli goes together with increased responses in frontal areas (i.e., ventromedial prefrontal cortex) and parietal spatial attention networks (Armony & Dolan, 2002; Palermo & Rhodes, 2007). The prefrontal activity is attenuated with amygdale reactivity to emotional stimuli. Further processing related to detailed emotion detection of facial expressions is likely to be found in cortical pathways and include regions in occipital and temporal neocortex (e.g., fusiform gyrus and superior temporal sulcus) (Adolphs, 2002a, 2002b; Palermo & Rhodes, 2007).

3.4.3 Neural circuits of attentional and affective control. Attentional control can be conceptualized as the ability to discharge irrelevant distracters. Affective control is thus the ability to discharge irrelevant *emotional* distracter. Recent evidence speaks for different neural routes involved in resolving interference from neutral and emotional stimuli (i.e., emotional distracters) (e.g., Egner, Etkin, Gale, & Hirsch, 2008). In particular, research from imaging studies has contributed to insight in this field. There is by now a wealth of research showing that conflict resolving is associated with lateral prefrontal cortex activity (Egner, 2007). However, recent research shows that a different route may be responsible for resolving conflict involving emotional stimuli. The emotional conflict route is suggested to involve the rostral anterior cingulated cortex inhibiting amydala responsiveness to task-irrelevant emotional stimuli. We thus have two conflict resolving neural circuits; (1) a lateral prefrontal "cognitive control" circuit that resolves conflict arising from non-emotional stimuli, and (ii) a rostral anterior cingulated "emotional control" system that is involved in resolving conflict stemming from emotional stimuli, and that is associated with decreased amygdala response to emotional distracters (Egner et al., 2008). In addition, Egner et al (2008) suggest that the dorsal anterior cingulated is engaged in conflict-detection involving both emotional and non-emotional conflict. Conflict resolution involving neutral and emotional distracters thus is likely to be governed by both overlapping and distinct neural circuits (e.g., Egner et al., 2008). These circuits seem to be effected differently by psychopathology (e.g., Monti, Weintraub, & Egner, 2010).

3.5 Measuring selective attention

Visual selective attention tasks can be divided based on the main type of tasks involved. The major groups of task belong in either of four categories; visual search and free viewing, filtering, multiple, and cueing tasks (Armstrong & Olatunji, 2012; Yiend, 2012). These categories are described below. The Stroop task and the Dot-Probe task are described in some detail as these modifications of these tasks were used in the studies presented in this thesis. Further, an introduction to how variations in presentation time might influence the interpretation of results from selective attention tasks is provided, along with limitations with response time measures.

3.5.1 Visual search and free viewing tasks. Visual search task involve that the participant searches for a target, typically a specific target in an array or distracting stimuli. The time until finding the target is commonly used as a measure of selective attention (Armstrong & Olatunji, 2012). The participant either has to respond upon finding the target, or eye tracking is used. In the latter case, time until first fixation is commonly used to quantify individual differences in biased attention (Armstong & Olatunji, 2012). In free viewing tasks a visual stimulus is presented and the participant views the image without specific instructions. Eye gaze is captured during the free viewing. Measures from free viewing include initial gaze orientation at stimulus onset as well as sum of fixations (when two stimuli are simultaneously presented) on the emotional versus neutral stimulus.

3.5.2 Filtering tasks. In filtering tasks, a target is presented among one or several distracters. Interference of the distracters on response time is commonly used as a quantification of bias. The Stroop task is a well-known paradigm in this category (Stroop, 1935). In the classic Stroop task, the participant have to report the color of a presented text, while the text is either color congruent (the word blue is written in blue text) or color incongruent (blue is written in red text). The responding is typically slower in incongruent trials in healthy participants, due to inference from the semantic meaning of the text. Interference is typically larger in psychopathological populations (e.g., dementia), with larger differences between congruent and incongruent conditions in such participants (Yiend, 2010). In a modification of the Stroop task, the emotional Stroop task (Williams, Mathews, & MacLeod, 1996), interference is typically larger when the text has an emotional meaning (e.g., disease) compared with trials where the text has a neutral meaning (Bar-Haim et al., 2007; Williams, Mathews, & MacLeod, 1996). Methodologically, blocked designs have been found to produce more reliable behavioral results with the emotional Stroop task (Bar-Haim et al., 2007).

3.5.3 Multiple tasks. Multiple tasks involve several tasks that are competing for attentional resources. Often two or several tasks, that all appeal for response, are presented in temporal proximity. Responses are likely to be biased toward one task, since it takes time to disengage and shift attention toward the next (Yiend, 2010). A typical multiple task is the attentional blink task (Raymond, Shapiro, & Arnell, 1992). The subjects are instructed to respond to two different targets that appear with some temporal distance in a row of other visual stimuli. The time between the presentations of target one and two is varied, as it has been shown that the target two is often missed when presented with short temporal distance after target one. This phenomenon is called “attentional blink” (Yiend, 2010).

3.5.4 Cuing tasks. In cuing tasks a specific location is cued with the presentation of a certain stimuli, after which a target appears at this or another location to which the participant have to react. Time to respond or accuracy of responses is used as quantifications of ABs in such tasks (Yiend, 2010). A typical cueing task the Dot Probe task (DPT). The DPT was first described by MacLeod and colleagues (McLeod, Mathews, & Tata, 1986). The task measures selective allocation of attention by measuring response RT to a target following the presentation of stimuli pairs, with one emotional and one neutral stimulus, in a number of successive trials. The participant has to respond as fast and accurate as possible to the target. AB scores are created by subtracting RT from emotional trials from RT from neutral trials (MacLeod et al., 1986). If the target appears at the location of the stimuli where the attention is located, the reaction time will be shorter than if the target is located on the opposite side of the attended stimuli (Posner, Snyder, & Davidson, 1980; Bradley, Mogg, White, Groom, & De Bono, 1999). A schematic trial in this task consists of the presentation of a matched stimuli pair (e.g., one emotional and one neutral face), followed by a target presented at the spatial location of one of the stimuli pair. In the initial versions of this task, the target was a dot, hence the name dot-probe task (MacLeod et al., 1986). The target appears with equal probability at the location of the two stimuli types in a stimuli pair. Thus differences in selective attention (i.e., differences in RT) to two groups (e.g., emotional and neutral) of stimuli can be inferred by comparing RT. AB indexes are usually created using RT data, by subtracting the RT to one stimuli group from another. Typically RT from emotional trials (e.g., happy faces) is subtracted from neutral trials (e.g., neutral faces) resulting in an AB score indicating selective attention toward or away from emotional stimuli (Bar-Haim et al., 2007). If mean RT in trials where the probe is under the emotional stimuli is subtracted from the mean RT in trials where the probe is under the neutral stimuli, a positive AB score indicates selective attention to emotional compared to neutral stimuli.

3.5.5 Presentation times

Different presentation times might partly capture different aspects of selective attention, such as orienting, engagement, and disengagement, which might influence the selective attention process (Clarke, MacLeod, & Guastella, 2013). When interpretations are made related to presentation time of the stimuli, the interpretation are usually based on models describing attentional processes as occurring along three temporal stages; (1) engagement with specific stimuli that are preferred over other stimuli based on stimuli type or location, (2) shifting of attention between different stimuli, and (3) disengagement from stimuli thus ending the preferential processing of a specific stimuli or location (Clarke et al, 2013; Posner et al., 1980). Shorter stimuli presentation may thus capture orienting to or the capturing ability of specific stimuli, while longer presentation times might capture engagement with specific stimuli (Bradley et al., 1998). More specifically, masked stimuli presented around 15-20 ms are subliminal and responses to targets after such stimuli might reflect biases in orienting. Conscious perception of stimuli occurs at presentation times around 100 ms (Posner, 1980), although goal directed deployment of attention may not be possible at such short presentation times. It takes about 200-300 ms to switch selective attention from one stimulus to another (Kenler, 1995), and presentation times shorter than 200 ms might thus reflect either capture or engagement with a specific stimulus. Longer presentation times, such as beyond 300 ms might reflect engagement, and presentation times above 1000 ms might reflect goal directed deployment of attention or elaboration (e.g., Yiend, 2012).

3.5.6 Stimuli characteristics

The most common stimuli in visual selective attention research concerning affective processes are faces (e.g., Joormann et al., 2007) and words (e.g., Jongen, Smulders, Ranson, Arts, & Krabbendam, 2007), but other stimuli have also been used, such as landscapes (e.g., Shane & Petersen, 2007). Some studies have employed stimuli related to a specific pathology, such as pain-related words for populations afflicted with chronic pain.

Differences in impact between word and picture stimuli have been highlighted (Holmes & Mathews, 1984). Word stimuli require semantic interference and images could thus be more potent (Bradley, Mogg, Falla, & Hamilton, 1998). Moreover, images are more likely to evoke evolutionary salient orienting responses (Ohman, 1993), as the morphology of a word does not carry any threat or reward information in itself. Another argument brought forward in favor of using images is that words are more likely to be used, and to be overly used when they are especially relevant in a specific group (e.g., anxious individuals use threat words more often), possibly interfering with group related responses (Bradley et al, 1998).

The target can also be varied, with newer studies often using different geometrical shapes. More recent studies often require participants not only to respond to the target, but also indicate the position or the shape of the target (e.g., two horizontal dots or two vertical dots) (e.g., Pourtois, Thut, Grave de Peralta, Michel, & Vuilleumier, 2005).

Image sets may include several images of the same emotional valence (e.g., several positive images). Typically, validated images or words are used, such as the NIMSTIM facial stimuli that includes ratings of valence intensity calculated (Tottenham, Tanaka, Leon, McCarry, Nurse, Hare, et al., 2009). Differences in the intensity of the emotional valence might have implications for results, as higher intensity of negative social images have been shown to capture and hold attention more than less intensive images, especially in healthy participants (Mogg, Garner, & Bradley, 2007; Yiend, 2012). For instance, two recent DPT studies evaluated the impact of "arousal" elicited by positive stimuli (Tamir & Robinson, 2007) and reported that only "high arousal" (i.e., rewarding) stimuli were preferred after a positive mood induction, while participants did not show an AB to "low-arousal" (i.e., pleasant) stimuli.

3.5.7 Limitations of response time as measure of selective attention. Most studies about selective attention uses paradigms where differences in attention are inferred from RT, including the emotional Stroop task (Williams, Mathews, & MacLeod, 1996), the dot probe task (MacLeod et al., 1996), and the emotional spatial cueing task (Fox, Lester, Russo, Bowles, & Dutton, 2011). A recent review noted that RT measures of selective attention are cost-effective and widely used (e.g, Armstrong & Olatunji, 2012). However doubts have also been raised about of how representative RTs are of the general selective attention of an individual, considering that each trial represent a single time point. In addition, key press responses might be affected by several confounding influences, apart from differences in selective attention. Limitations include that the response through key press is likely to be influenced by intermediate information processing (occurring between stimulus presentation and press) as well as differences in executive ability between subjects (e.g., Armstrong & Olatunji, 2012). Alternatives to RT measures include eye-tracking as well as physiological markers of biases including fMRI (Armstrong & Olatunji, 2012). Response biases can be avoided or reduced by using neutral response alternatives (i.e., avoiding response labels as plus and minus, or positive and negative), and to present the response target at a time point when other stimuli are not present on the screen (Yiend, 2010).

3.6 Typical attentional biases in healthy and psychopathological populations

In this section typical findings regarding attentional biases in healthy (3.5.1) and psychopathological (3.5.2) populations are presented.

3.6.1 Attentional biases to emotional stimuli in healthy populations. Although results with ABs must be interpreted against the background of the particular paradigms in use, a few consistent results pertaining to biased attention to emotional stimuli in healthy participants have been found over most paradigms (Yiend, 2010). These include a bias to strong threat signals as well as a preference of emotional (positive and negative) versus neutral stimuli in general (Yiend, 2010). In addition, emerging research point to increased biased attention *toward* threat stimuli in dangerous situations predicts lower rates of psychopathology including both depression and PTSD later on (Bar-Haim, Holoshitz, Eldar, Frenkel, Muller, Wald, et al., 2010; Wald, Schchner, Bitton, Holoshitz, Charney, Muller, Bar-Haim et al., 2011).

3.6.1.1 Threat bias in healthy subjects. Threatening stimuli, such as angry faces, are evolutionary salient, and as such are preferred in attentional processes (Ohman & Mineka, 2001). An angry face in a happy crowd stands out, but a happy face in an angry crowd does not (Kahneman, 2012; Ohman & Mineka, 2001). The following thought experiment (borrowed from Kahneman, 2012) provides a way of intuitively understanding the difference in attentional and cognitive responses related to pleasant and unpleasant stimuli" *one cockroach in a bowl of strawberries totally cancels the effect of the strawberries, but one strawberry in bowl of cockroaches does not cancel the effect of the cockroaches*".

A detected threat stimulus instantly and "automatically" cancels processing of other available stimuli and orients the organism toward the threat (McEwen, 2007; Ohman &

Mineka, 2001). This rapid orientation to threat is an adaptive response; since a real threat might require quick behavioral action (e.g., Ohman & Mineka, 2001). Biases to emotionally negative stimuli measured with behavioral tasks generally also found early in the attentional process, in particular after presentation times around 100 ms (Yiend, 2010).

3.6.1.2 Avoidance of mild threats in healthy subjects. Although a bias to strong threats (i.e., highly unpleasant, evolutionary salient) is found in healthy subjects, avoidance to mild threat has also been detected with some consistency in healthy controls using filtering and cueing tasks (contrasted with the bias to mild threats found in anxious populations) (e.g., Bar-Haim et al., 2007; Yiend, 2010). Thus the intensity of the threat stimuli is of importance as a factor that mediates results with such stimuli in both healthy and pathological populations (Bar-Haim et al., 2007).

3.6.1.3 Bias to threat stimuli in dangerous situations. Bar-Haim et al. (2010) recently investigated people under life-threatening circumstances (i.e., rocket attack) to find out if their attention were directed toward or away from threat cues. They found that approximation to war-zone increased avoidance of threat cues, with more avoidance of threat the closer the danger the measurement was made. Interestingly, higher avoidance of threat was associated with higher rates of depression, PTSD and anxiety (higher approximate to the danger zone was also related to higher symptoms) (Bar-Haim et al., 2010). Another study measured threat bias in soldiers before and 23 weeks after military deployment (i.e., Israeli defense force, paratroopers) (Wald et al., 2011). The results showed that higher avoidance of threat at baseline predicted higher PTSD symptoms (Wald et al., 2011). These results indicate that higher attention to threat (i.e., lower disengagement from threat stimuli in such situations) is indicative of resilience later on.

3.6.1.4 Biases to positive stimuli in healthy subjects. A rapid response to positive stimuli does not seem to be hardwired in the same way as to threat stimuli (Kahneman, 2012;

Troy & Mauss, 2011; Yiend, 2012). However, several AB tasks (including e.g., viewing tasks) have found preliminary results showing that *all* emotional stimuli are preferred to and attended more to than neutral stimuli (Frischen, Bayliss, & Tipper, 2007). That means that both positive and negative stimuli engage attention and draws on attentional capacity more than neutral stimuli do (Frischen et al., 2007; Palermo & Rhodes, 2007; Yiend, 2010).

Although sufficient research is lacking, preliminary result point to that subjects specifically picked out to have low vulnerability to psychopathology (e.g., scoring low on anxiety or depression symptomatic, lacking family history of psychopathology, carriers of specific protective genes) might show distinct biased attention, including AB to positive stimuli (e.g., Frewen et al., 2008; Joorman et al., 2007). Further, studies showing a relation between more attention to positive stimuli and positive emotion (Tamir & Robinson, 2007), better emotion regulation (Fox et al., 2010) has been found. In addition, indirect evidence come from studies training or instructing subjects to focus on positive stimuli, where such focus goes together with better emotion regulation (Johnson, 2009; Taylor et al., 2010). A complete overview of available studies with positive stimuli in the Dot-Probe task is provided in appendix (see appendix 1). Generally, research into protective ABs is lacking and important since such research could provide important information about what clinical interventions that should be conducted (Yiend, 2010).

3.6.2 Attentional biases in stress-related psychopathology. Psychopathologies, such as depression and anxiety, influence all dimensions of individual responding including perception, physiological reactions, cognitions and behavior (Cohen, Kessler, & Gordon, 1997). Several consistent biases have been found in anxiety and depression including an AB to threat information in anxious subjects (Bar-Haim et al., 2007; Yiend, 2010), and an AB to sad stimuli and away from positive stimuli in depressed subjects (Armstrong & Oljatunji, 2013; Peckham et al., 2010). ABs have been found in other types of disorders, such as pain, eating disorders, and substance abuse and these might also interaction with the experience of stressors, however these are beyond the scope of this thesis (but see e.g., Yiend, 2010).

3.6.2.1 Threat bias in anxiety. A robust threat bias has been found in both clinical and sub-clinical anxiety (Armstrong & Oljatunji, 2013; Bar-Haim et al., 2007; Yiend, 2010). While healthy subjects avoid mild threats in non-stressful situations, anxious subjects react stronger to such stimuli (e.g., Bar-Haim et al., 2007). The bias in anxiety might be a early strong evaluation of threats as more intensively threatening than in healthy participants, or it might be an attenuation to threat that causes a rapid reactions over sub-cortical pathways related to orienting. However, both higher detection and prolonged engagement with threat stimuli have been found in anxious subjects, indicating that both higher sensitivity to threats and lacking attentional control contribute to the disorder (Yiend, 2010).

3.6.2.2 Bias to sad stimuli in depression. The AB to sad stimuli is most consistent after longer presentation times, and thus seem not to be a deficit in detection of negative stimuli, but rather an inability to disengage from such stimuli (e.g., Armstrong & Oljabunji, 2013; Mathews & Mackintosh, 1998; Peckham et al., 2010; Yiend, 2010). Biases are most likely to occur for self-relevant sad stimuli (Peckham et al., 2010). A recent meta-analysis suggests that more reliable biases are found with presentation times over 1000 ms to sad stimuli in depression (Peckham et al., 2010). Subliminal biases, similar to those found to threat stimuli in anxiety, were not supported by the meta analysis (Peckham et al., 2010).

Interestingly, depressed subjects have also been found to not show inhibition of return (IoR) effects. IoR suppresses attention to an attended location (e.g., the location of a primer) somewhere around 300 ms and until around 3000 ms (Posner & Cohen, 1984). IoR is commonly thought to prime attention to novelty, by suppressing engagement with a recently attended location. Depressed subjects have been found to not show IoR effects for negative stimuli (Leyman, De Raedt, Schacht, & Koster, 2007). This finding is in line with research about depression showing that depressed subjects show a deficiency in disrupting their attention to negative material (e.g., Yiend, 2010).

3.6.2.1 Bias away from positive stimuli in depression. Attentional biases to positive stimuli in depressed subjects are less well researched than biases for negative stimuli (Yiend, 2010). However, meta analysis results suggest a bias away from positive stimuli in depressed subjects as measured with eye-tracking (Armstrong & Oljatunji, 2013). The study found that depressed subjects both oriented less to positive stimuli and maintained their gaze to such stimuli for shorter times (Armstrong & Oljatunji, 2013).

A few recent studies also suggest that a failure to exhibit enough biased attention to positive stimuli might underlie depression (Harmer & Cowen, 2013). Evidence from this line of research show that increased attention toward positive stimuli precedes reduction of depression symptoms after medication with selective serotonin reuptak inhibitors (SSRIs) (Harmer, 2008; Harmer & Cowen, 2013). Such findings indicate a central role for ABs to positive stimuli in the etiology of depression (Harmer & Cowen, 2013).

3.7 Attentional control in healthy and psychopathological populations

This section reviews typical finding on attentional control in healthy and populations affected by stress related disorder. Findings for attentional and affective control are fused in this section, to reflect earlier reporting on control to both neutral and emotional stimuli.

3.7.1 Attentional control in healthy populations. Findings within this field are preliminary, however a few general finding can be put forward. These findings are related with attentional control rather than affective control proper, but we will still shortly review them as they provide important insight. Attentional control is affected by conflict, emotion and stress (Goscheke, 2014). As outline in the model section, conflict monitoring strongly influences the exhibition of attentional control in healthy subjects (Botvinick et al., 2011; Egner, 2007). In addition, recent research show that attentional control is affected by emotions, for instance negative emotions have a task-shielding effect, while positive emotions invites to a broadening of attention (Goscheke, 2014). Finally, and most important to this thesis, attentional control is affected by both acute and chronic stress. Several studies have found that stress induces a stronger likelihood for bottom-up processing in contrast with top-down modulation of attention (Goscheke, 2014; Ramos & Arnsten, 2007). In addition, stress seems to reduce flexible adaption of attention to the context, such that the conflict adaption in such situations is lowered (Gray et al., 2009; Plessow, Fischer, Kirschbaum, & Goscheke, 2011a). Findings related more precisely with affective control and stress is reviewed further in chapter 4.

3.7.2 Attentional control in stress-related psychopathology. There are two main findings related with affective control and stress-related psychopathology; (i) anxiety is related with lowered control that affects all instance of threat processing, and (ii) depression is related with a decrease in control to negative stimuli that affects elaboration of such stimuli.

3.7.2.1 Attentional control in anxiety. Findings with anxious individual show that attentional control is dysfunctional in such populations (Bishop, 2009; Etkin et al., 2011). This seems to be related with decreased ability in a range of areas, such as emotion regulation and inhibition of responses to threat. Within a conflict adaptation framework, it has been suggested that impaired emotion regulation in anxious population (related with dysfunctions of a dorsal ACC and medial PFC route), together with decreased function of top-down regulation of emotion (related with impairment in a ventral-rostral medial PFC route) lead to difficulties in fear regulation (Etkin et al., 2011; Goscheke, 2014).

3.7.2.2 Attentional control in depression. Decreased ability to inhibit attention toward negative distracting stimuli, in particular to sad self-relevant distracters, is commonly found in depressed populations (Gotlib & Joormann, 2010). More precisely, depression seems to go together with a difficulty to disengage from negative internal stimuli (Gotlib & Joormann, 2010). Interestingly, while healthy controls are characterized by increased recruitment of attentional control in the face of conflict and errors, this seem not to be the case in depressed individuals (Goscheke, 2014; Menon, 2011; Pizzagalli, 2011). It has therefore been suggested that the increased negative affects (related with hyperactivity of ventral PFC and limbic areas) together with deficits in deficits in recruitment of affective control (related with hypo activity in dorsolateral PFC and ACC) lead to lowered ability to disengage from negative internal stimuli (Goscheke, 2014; Pizzagalli, 2011).

Chapter 4 – Rationale of this thesis

The prime aim of this thesis was to investigate how individual differences in selective attention to emotional stimuli relate to individual differences in resilience. Cognitive-behavioral stress models suggest that selective attention is as an essential component of stress-reactivity (Beck, 1976; Lazarus & Folkman, 1984). For instance, the classic stress appraisal model suggested by Lazarus and Folkman states that the content of selective attention of the individual precedes appraisals of the current situation and available resources that in turn results in specific coping mechanisms and behaviors. This stress appraisal model states that for a situation to become stressful, it must be perceived as stressful by the individual (Monroe & Kelly, 1997). Stimuli that are attended might function as “triggers” and elicit further emotions, cognitions and behaviors. Therefore differences in selective attention, might lead to totally different perception of a situation. For instance, an enhanced biased attention (i.e., representation) of positive stimuli might lead to increased detection of positive stimuli with higher positive mood and more reward attainment as possible consequences (example adapted from Yiend, 2010, p.5). Thus, differences in selective attention might stand in relation with differences in stress responses and resilience (Lazarus & Folkman, 1984; Monroe & Kelly, 1997; Todd et al., 2012; Ochsner & Gross, 2005; Troy & Mauss, 2011). In other words, individual differences in selective attention, such as differences in biased attention to positive stimuli or affective control, might explain why two individuals, confronted with the very same stressful event, react to the event in two very different ways.

Several recent theoretical accounts have proposed selective attention can be understood as a form of emotion regulation. Such attentional emotion regulation can, if adaptive, lead to higher resilience (Todd et al., 2012; Ochsner & Gross, 2005; Troy & Mauss, 2011; Scherer & Ceschi, 1997). These accounts are highly relevant, as stressful situations are highly emotional, and individual differences in emotion regulation might become amplified in stressful situations (Sarason, Johnson, & Siegel, 1978). Emotions have been defined as "*transient, bio-psycho-social reactions shaped by evolution to aid individuals in adapting to and cope with events that have implications for survival and well-being*" (Matsumoto & Ekman, 2010, p. 342). Emotions thus guide us to what is important and helps elicit further action related to such stimuli. When we *perceive stimuli* that are of importance to us, we will experience emotion and act on that emotion (Matsumoto & Ekman, 2010). Cognitive processes involved in regulation of emotions include (1) increased focus on the emotional stimuli and decreased attention to distracters, and (2) emotional response activates memories related to situations that are mood-congruent, thus *reducing* novel behaviors and cognitions (Matsumoto & Ekman, 2010).

Attentional deployment as emotion regulation is typically used when the subject cannot chose or modifies emotion regulation through change of situation (Werner & Gross, 2010). Most research in this field has focused on dysfunctional selective attentional strategies, including for instance rumination, worry and distractions (Werner & Gross, 2010). Rumination involves repetitive evaluation and feelings that are associated with past events, in particular negative events (e.g., Morrow & Nolen-Hoeksema, 1990; Werner & Gross, 2010). Worry is anticipation of future (negative) events (Werner & Gross, 2010). Increased worrying can function as a distracter from strong unpleasant physiological stress, while the focus on future threats reduced the attention to the physiological reaction (e.g., Borkovec, 1994). However, such distraction leads to adverse long-term consequences, as it prevents habituation to emotional reactions (Butler & Gross, 2004) and also reduced performance (e.g., decision making) in the stressful situation (Metzger, Miller, Cohen, Sofka, & Borkovec, 1990). Similar to worry, other types of distraction leads to decreases in habituation an well as less resources to solve current problems, which may be less adaptive in the long run (Werner & Gross, 2010). However, distraction is a common emotion regulatory strategy that might also be positive through regulating mood toward more positivity and prevent rumination or worrying (Nolen-Hoeksema, 1993). In contrast, very little is known about adaptive selective attentional strategies related with stress resilience.

However, recently several theoretical accounts for how selective attention can be protective in stressful situations have been suggested. These accounts can be classified along two distinct lines of research. First, it has been suggested that *more biased attention to positives stimuli* regulate the organism toward more positive mood and stronger reward focus (Todd et al., 2012). Second, it has been suggested that *higher affective control* lead to better emotion regulation and more flexible conflict adaption that in turn leads to higher resilience (Ochsner & Gross, 2005; Troy & Mauss, 2011).

In the following chapter, these two lines of theory about selective attention to emotional stimuli and resilience are outlined, starting with biased attention, followed by affective control. Thereafter two main questions for this thesis are formulated, building on earlier findings from stress research, and finally, conclusions from the literature, the aims and main hypotheses of the presented studies are provided.

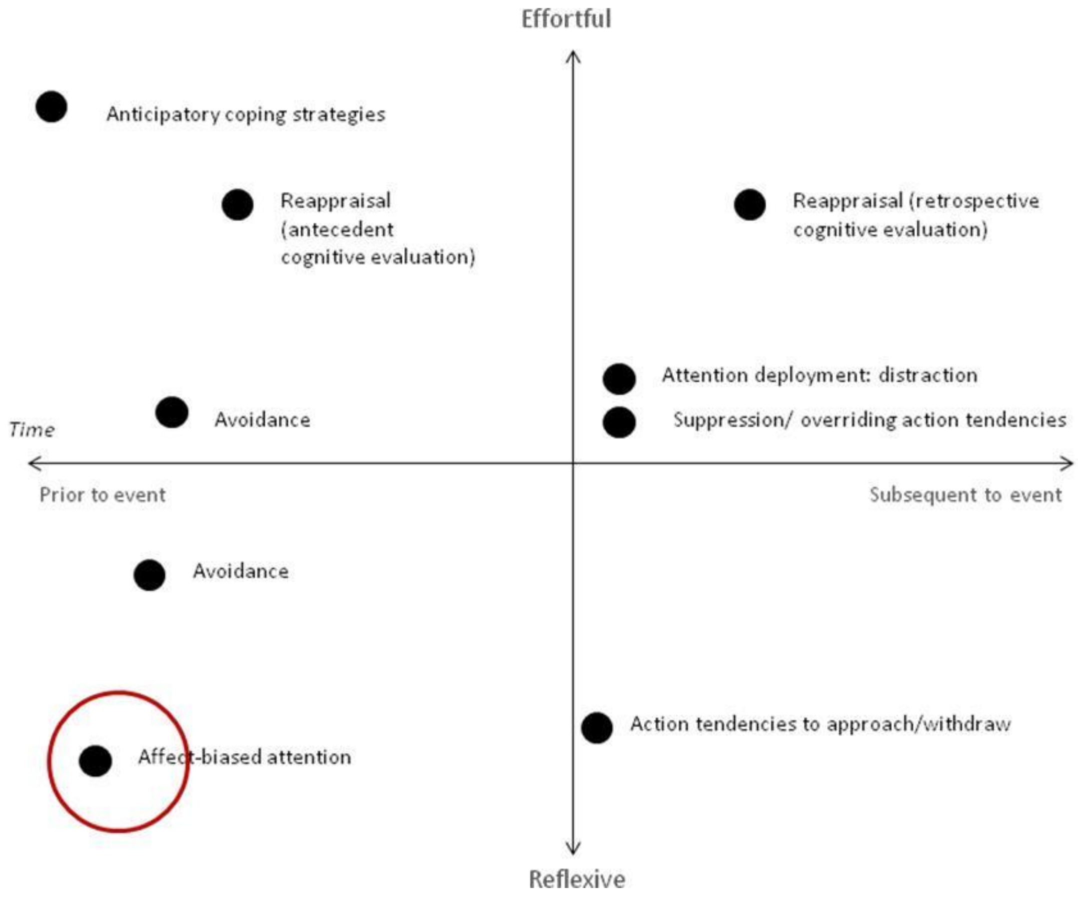
4.1 Biased attention as emotion regulation

Affect biased attention has been suggested to play an important role in emotion regulation (Todd et al., 2012). Affect biased attention is defined as "*attentional biases that give rise to preferential perception of a particular category of stimulus based on its relative affective salience*" (Todd et al., p. 365). As can be seen in figure 6, biased attention is thought to be largely un-reflected and characterized by "automaticity[4]" compared with regulation taking place further down the cognitive process (e.g., suppression). However, affect-biased attention is ongoing, and might take place in anticipation or in reaction to an event, or might be related to rapid orienting and later engagement with a stimulus, and might be related to both bottom-up and top-down biases (Todd et al., 2012). As already outlined in chapter 3, bottom-up biased attention are related to rapid identification of certain features of stimuli (e.g., shape of eyebrows), that in turn releases an immediate heightened attentional state.

Such biased attention is associated with emotion regulation of negative feelings, such as anxiety or aggression that are in turn related to avoidance and approach respectively. Top-down biases, on the other hand, are related with current goals or learned habitual attention toward certain stimuli groups in a certain context. However, top-down biases must not be felt as effortful in the same way as when, for instance, we direct our attention to specific stimuli after conscious consideration (e.g., after instruction to do so). Instead, such effortful biased attention might become automatic after many repetitions (Todd et al., 2012). The cause of individual differences in affect-biased attention might thus be both differences in bottom-up processing as well as differences in learned habitual application of selective attention toward stimuli of a certain valence (Todd et al., 2012).

Affect-biased attention is thus understood as attentional pre-tuning to attend to stimuli of certain emotional valence in certain context (Todd et al., 2012). Further, affect-biased attention guide behavior towards affect congruent actions. It should be noted however, that such actions might differ between individuals. For instance biased attention to stressful stimuli can elicit both aggression and anxiety depending on individual specific factors.

Figure 5. Affect-biased attention as emotion regulatory category



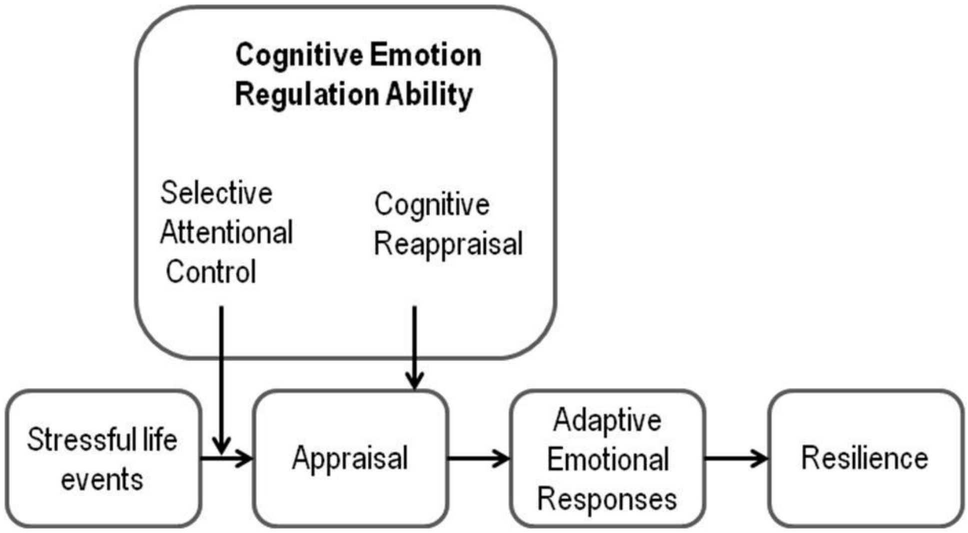
Note: Figure adapted from Todd et al. (2012). In the circle: Affect-biased attention is defined as pre-event emotion regulation through the activation of representations that tunes attention toward stimuli that elicits a specific affect.

4.2 Affective and attentional control as emotion regulation

Ochsner and Gross (2005) have proposed a model of emotion regulation specifically pertaining to stress, where attentional control has a central role, the model is visualized in figure 7. Attentional control is defined as the ability to selectively attend to different types of stimuli in situations, in other words to control the emotional impact of stimuli (Ochsner & Gross, 2005). This model assumes that attentional control is closely linked to cognitive appraisals (evaluations) of stimuli. There is empirical evidence for such an assumption, for instance attention to positive stimuli has been found to increase positive reappraisals (Totterdell & Parkinson, 1999).

In this case attentional control is seen as regulating emotion through early attentional selection and more precisely through disengaging from certain emotional information. This is therefore a processes taking place before a more elaborate processing. Information that passes into elaboration is instead regulated through later cognitive strategies, such as modifying appraisals (e.g., Gross, 2007). A common idea related to how attentional control might influence emotion regulation is that such regulation involves a relatively low cost-benefit tradeoff. Early regulation of emotional material must not engage in the more forceful and demanding later modulation of cognition and emotion (Sheppes & Levin, 2013).

Figure. 6. Attentional control impacts stress resilience



Note: Figure adapted from Troy and Mauss. (2013). This model emphasis the role of attentional control, i.e. the ability to direct attention to for instance stimuli of a certain emotional valence, and places this type of regulation as preceding cognitive reappraisals.

4.3 Main research questions

How can regulation of selective attention to emotional stimuli be related to resilience? Based on the reviewed literature and the two main models relating selective attention with resilience, we can formulate two main research questions:

(i) Is higher biased attention to positive stimuli related with higher stress resilience?

(ii) Is higher affective control, i.e., higher ability to flexibility focus on task-relevant emotional stimuli and discharge emotional distracters, related with stress resilience?

These main questions will be answered through investigating available empirical evidence and through the empirical studies included in this thesis.

4.4 Is higher biased attention to positive stimuli related with higher stress resilience?

The majority of the available theoretical models and empirical evidence about biased attention and stress regulation involves biases to negative stimuli (Yiend, 2010). Such studies typically find a relationship between higher attention to negative stimuli and more stress-related psychopathology (Bar-Haim et al., 2007; Peckham et al., 2010). However, as outlined above, it has been proposed that more attention to positives stimuli regulates the organism toward more positive mood and stronger reward focus and thus toward higher resilience (Todd et al., 2012; Yiend, 2010). Such accounts suggest that enhanced representation of positive stimuli might lead to increased detection of positive stimuli in the environment with higher positive mood and more reward attainment as possible consequences. A few empirical studies support such accounts, showing for instance that higher biased attention to positive stimuli is related with low anxiety (Frewen et al., 2008) and low vulnerability to depression (Joorman et al., 2007), as well as more experience of positive emotion (Ong et al., 2006). Frewen et al. (2008) analyzed 13 studies including high- and low anxious participants that all had conducted a cuing task. They found biased attention away from the positive stimuli in the anxious group, and a bias toward positive stimuli in the non-anxious group. Frewen and colleagues (2008) suggested that individual differences in biased attention might be due to higher reinforcement of such stimuli (i.e., higher previous attention to such stimuli), in turn leading to stronger neural connections "wired" to such stimuli. Joorman et al. (2007) found that girls with a maternal history of depression avoided positive stimuli in a cueing task, while girls without such a history instead had a bias toward positive stimuli.

A possible explanation for why more biased attention should predict higher resilience is that such attention enable the individual to "bounce back" from stress, by breaking off prolonged attention to negative emotions and cognitions that might be prevalent during stress (Cohn et al., 2009). Bouncing back has been consistently related with the experience of positive emotions (Cohn et al., 2009; Fredrickson, 2013; Tugade & Fredrickson, 2007 and biased attention to positive stimuli might be a precursor, or might amplify positive emotions and thus function as a "trigger" of positive emotions.

Thus, we can conclude that there is both theoretical and empirical evidence suggesting that higher biased attention to positive stimuli is associated with higher resilience. However, the evidence is indirect (i.e., relationship between lower biased attention to positive stimuli and stress-related psychopathology). In contrast, direct assessment of biased attention to positive stimuli together with resilience has not been reported in the available research literature.

4.5 Is higher affective control, i.e., higher ability to flexibility focus on task-relevant emotional stimuli and discharge emotional distracters, related with stress resilience?

Affective control might be strongly related with the ability to flexibly focus to and away from threat stimuli. Strong threats stimuli have priority in the attentional processes, as such stimuli is evolutionary salient (e.g., LeDoux, 2000). However, dysregulation of attention to threat is related with psychopathology, in particular with anxiety (Bishop, 2009). Anxious individuals typically show hyper vigilance to irrelevant threat stimuli (Bar-Haim et al., 2007; Bishop, 2009). Healthy individuals, on the other hand, avoid mild threats in situations that are not dangerous or stressful (Palermo & Rhodes, 2007; Yiend, 2010). However, bottom-up processing of intensive threat stimuli in non-stressful situations is seen in anxious and healthy subjects alike, and such processing is adaptive (Palermo & Rhodes, 2007; Yiend, 2010). Further, recent evidence show that strong avoidance of threat before or during a dangerous situation predicts lower resilience and more stress-related disorder (PTSD, depression) (Bar-Haim et al., 2010; Wald et al., 2011). Based on such findings, we can conclude that the sensitivity and exactness of threat detection together with an adaptive ability to discharge irrelevant distracting threat stimuli seem to be of importance for stress resilience.

A relationship has also been established between lowered attentional control and depression (Goeschke, 2014). Of particular interest is the relationship between failure to terminate negative elaboration (i.e., prolonged engagement with internal negative stimuli) and lowered attentional control (Goeschke, 2014). It has been found that depressed subject fail to recruit attentional control in response to conflict contributes. The failure has been suggested to contribute to the often-found failure to disengage from negative stimuli in depression (Goeschke, 2014). Several studies have found that attentional control mediates the relationship between rumination and stress. For instance, a recent study found that impaired control (i.e., larger switching costs in a switching task) mediated the relationship between stress and rumination six weeks later (De Lissnyder, Koster, Goubert, ONrraedt, Vanderhasselt, & DeRaedt, 2012). This finding is in line with other studies finding an association between lower attentional control and an increase in rumination and intrusions (Haagenar & Putman, 2010).

A few recent studies have investigated how *stress affects attentional control* (Gray et al., 2009; Plessow et al., 2011a; Plessow et al., 2011b). These studies have found a decrease in attentional control in response to both acute (Plessow et al., 2011a; Plessow, Kiesler, & Kirschbaum, 2011b) and chronic stress (Gray et al., 2009). Plessow et al. (2011a, 2011b) found that attentional control (measured with a switching task) was decreased following a standardized psychosocial stressor (i.e., the Trier Social Stress Test) compared with participants that had not undergone any stressor. Gray and colleagues (2009) measured attentional control (with a switching task) during a period of chronic stress. Control was positively correlated with perceived stress in this study, and the decrease was reversed after termination of the stressor (Gray et al., 2009).

In addition, one study investigated how affective flexibility (measured with a flexibility task) is related with trait resilience (Genet & Siemer, 2011). In this study, the participants conducted several behavioral tasks measuring attentional and affective flexibility, as well as working memory capacity together with a self-rate measurement of trait resilience. The result showed that attentional and affective control were unique predictors of trait resilience (Genet & Siemer, 2011).

4.4 Conclusions and hypotheses

As discussed above, both theoretical accounts and empirical evidence suggest that differences in selective attention to emotional stimuli might influence individual differences in resilience. Possible pathways of resilience are directed both over the magnitude of attention to positive (and negative) stimuli, and over individual differences in affective control. It is by now well known that stress-related disorders, such as anxiety and depression, are related to increased attention to negative stimuli (e.g., Bar-Haim et al., 2007; Peckham et al., 2010) and to lower affective control (e.g., Goeschke, 2014). In contrast, less is known about adaptive selective attention in relation with stress resilience. Further, research investigating selective attention to emotional stimuli in healthy and highly resilient subjects has been put forward as a priority, as evidence from such research is needed to guide clinical prevention and treatment (Yiend, 2010).

The main aims of the thesis were formulated as follows:

(i) Investigating how biased attention to emotional (positive, negative) stimuli is related with trait stress resilience

(ii) Investigating how affective control is related with (i) trait resilience and, (ii) emotional responses to a laboratory stressor.

The main hypotheses were

(i) Higher biased attention to positive stimuli is associated with higher resilience.

(ii) Higher affective control is related with (a) higher trait resilience, and (b) more adaptive emotion reactivity to a laboratory stressor

Chapter 5 – Empirical studies

In the following chapter, the two original works included in this thesis are presented. The original work comprises results from three experimental studies structured in two articles. The introduction, method, results and discussion of the two articles are presented below.

5.1 Abstracts

5.1.1 Attentional bias toward positive stimuli predicts stress resilience. There is extensive evidence for an association between an attentional bias (AB) toward emotionally negative stimuli and vulnerability to stress-related psychopathology. Less is known about whether mental health and stress resilience may also relate to selective attention toward emotionally *positive* stimuli. The current study used a modified Dot Probe task to investigate if individual differences in AB toward either happy or angry emotional stimuli are related to self-reported stress resilience. In a nonclinical sample (N=43), we indexed AB as individual differences in reaction time for stimuli preceded by either happy or angry (compared to neutral) face stimuli. Participants with greater AB toward happy, but not angry faces reported higher resilience. An AB towards angry stimuli moderated this effect: The AB toward happy faces was only predictive in those individuals who also endorsed an AB towards angry stimuli. This finding suggests that (1) an AB toward positive emotional stimuli may be a protective factor contributing to stress resilience, specifically in those individuals also endorsing an AB to negative emotional stimuli and, (2) that such an attentional bias may offer a novel target for prevention and treatment interventions addressing stress-related psychopathology.

Keywords: attentional bias, resilience, positive, emotion, dot probe task

5.1.2 Affective control predicts stress resilience and emotional reactivity to a laboratory stressor The ability to focus on task- relevant emotional stimuli and disregard emotional distracters, so called affective control, has been suggested to amplify emotion regulation during stress. During stress exposure, higher affective control may increase the capacity to attend to an.d pursue a task at hand. In two studies, we investigated whether individual differences in affective control, indexed by a modified Stroop task, predicts (i) trait stress resilience and (ii) emotional reactivity to a laboratory stressor. As hypothesized, greater affective control predicted higher trait stress resilience (b=.27, p= .041), and more adaptive emotional reactivity in response to a laboratory stressor, i.e., decline in positive mood (b=-.22, p= .029) and affective reactivity (b=.20, p= .017) in response to a standardized laboratory stressor. These results show that greater affective control is related to increased self-reported stress resilience, as well as more adaptive emotional reactivity to a laboratory stressor. Our findings suggest one possible pathway to resilience, with higher affective control leading to better emotional reactivity to stressors. These results might contribute to the development of prevention and treatment options for stress related disorder.

Keywords: Affective control, conflict adaptation, emotion, resilience, Stroop task

5.2 Attentional bias toward positive emotion predicts stress resilience

5.2.1 Introduction. Prior studies consistently show an association between an attentional bias (AB) to threatening stimuli and the development and maintenance of anxiety (Bar-Haim et al, 2007; Frewen, Dozois, Joanisse, & Neufeld, 2008). Selective attention to positive material has received considerably less attention. This is somewhat surprising, as it is known that an AB toward positive stimuli may facilitate adaptive stress regulation by preventing negative emotional responses to stressors and increase reward direction (e.g., Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007). An AB towards positive information may therefore play an important role in determining mental health and stress resilience, i.e. adaptive psychological and physiological responding to stressors (e.g., Feder, Nestler, & Charney, 2009).

Initial studies suggest that an AB to positive stimuli is related to the absence of psychopathology. Frewen and colleagues reviewed 14 studies investigating AB toward reward-relevant stimuli and concluded that an AB toward positive stimuli was associated with low anxiety (Frewen et al., 2008). Several recent studies have confirmed the association between AB toward positive stimuli and absence of psychopathology (Peckham et al, 2010; Mingtian, Jinyao, Shugiao, & Atchley, 2011; Taylor, Bomyea, & Amir, 2010) as well as low vulnerability to depression (Joormann et al., 2007).

A handful of studies have specifically investigated AB toward positive stimuli in the context of stress adaptation. In one study, AB toward positive stimuli predicted less subjective stress to a laboratory stressor four months later (Fox, Cahill, & Zougkou, 2010). Participants with higher AB toward positive stimuli have also been shown to show mitigated stress responses and to endure longer on a stressful anagram task (Johnson, 2009). Interestingly, an AB away from negative stimuli also predicted reduced stress in response to both laboratory (Fox et al., 2010) and naturalistic stressors (Fox et al., 2010; MacLeod & Hagan, 1992; Osinsky, Lösch, Hennig, Alexander, & MacLeod, 2012). Taken together, these studies suggest that an AB toward positive, and possibly away from negative stimuli, predicts stress resilience. However, these prior studies indexed stress coping as a reduction in negative emotions or the absence of depression and anxiety and did not specifically assess stress resilience. Moreover, most studies investigate separate influences of AB toward positive and negative stimuli on stress coping, without taking into account the possibility that the biases may interact, such that an AB toward negative stimuli may modulate the effect of an AB toward positive stimuli.

The present study indexed AB with the frequently used Dot Probe Task (DPT; MacLeod, Mathews, & Tata, 1986). A stimulus pair, typically one emotional and one neutral stimulus, is presented simultaneously in two separate locations. This followed by a target in one of the two locations, and the participants have to classify this stimulus as fast as possible. If the emotional stimulus is selectively attended, participants respond faster to the probe at the location of the emotional stimulus compared to the neutral stimulus, resulting in an AB. Target detection is generally held easy in the DPT, with typical error rates around one percent (e.g., Mogg et al., 1997). This may lead to individual differences in how difficult the task is for participants due to ceiling effects. In order to increase task sensitivity, we therefore created a modified version of the DPT that included a pre-DPT adjustment of individual difficulty level of probe detection.

The main aim of the present study was to investigate the association between AB toward emotionally positive and negative facial stimuli and individual differences in stress resilience. We hypothesized that (i) an AB toward positive face stimuli would predict greater stress resilience. We also explored whether (ii) an AB away from negative face stimuli would predict stress resilience and (iii) whether an AB toward negative stimuli moderates the association between AB toward positive stimuli and resilience. Understanding factors that promote resilience in the face of stress is crucial for the development of stress prevention programs and for improving treatment of stress-related disorders.

5.2.2 Method.

5.2.2.1 Participants. Forty-three (11 male, 32 female) healthy adults participated in exchange for 25 Swiss Francs (27 US$ at time of testing). All participants were right-handed and had normal or corrected-to-normal vision. The mean age of participants was 27 years (*SD* = 6.50). The local ethic board approved the study and all participants gave their informed consent.

5.2.2.2 Measures.

5.2.2.2.1 Self-reported stress resilience. Stress resilience was measured with the German version of the Resilience Scale (RS-11; Wagnild & Young, 1993; Schumacher, Leppert, Gunzelmann, Strauss, & Brähler, 2005). The RS-11 comprises 11 items ranging from 1-7, and answers are added up to a sum score indexing trait resilience, with higher scores reflecting greater trait resilience. The RS-11 has high internal consistency (Cronbach α= .91), and has shown convergent validity with related constructs. Internal consistency was high in the present sample, α= .84.

5.2.2.2.2 Modified Dot Probe Task. The experimental task was a modified DPT (McLeod, Mathews, & Tata, 1986), see Figure 1A-B. Each trial included (1) the presentation of a central fixation point that was constantly shown on the screen, (2) a 200 ms presentation of a face pair consisting of an emotional (i.e., happy or angry) and a neutral face, followed by (3) a 200 ms presentation of a pair of Landolt ring stimuli (Schrauf & Stern, 2001). One of these Landolt stimuli contained an opening in the upper or lower part of the ring, the other stimulus did not contain any opening. Participants were instructed to indicate as fast and accurately as possible if the Landolt opening was located up or down by pressing one out of two response keys. Before the actual experimental task, the difficulty level was individually adjusted for each participant[1]. The thresholding procedure was identical to the experimental paradigm safe for three aspects: (1) the angle of the Landolt opening was varied, (2) the stimulus pairs included different NIMSTIM faces (Tottenham, Tanaka, Leon, McCarry, Nurse, & Hare, et al., 2009), and

(3) the procedure was terminated as soon as enough responses had been given to determine the

individual Landolt angle resulting in 80% correct responses for this participant (*M* = 9.33°, *SD* = 5.91°). This calculated angle was used in the two sessions of the experimental paradigm. No feedback about response correctness was given after each trial. The experiment (excluding the threshold task) consisted of two sessions of 192 trials each. Each session lasted approximately 10 minutes.

5.2.2.2.3 Stimuli and apparatus. The face and target stimuli were presented on a computer monitor (36.5 cm wide and 27.5 cm high) using a Windows PC computer and Cogent 2000 (http://visilab.ucl.ac.uk/cogent_2000.php) running in MATLAB (MathWorks, Natick, MA, USA). All stimuli were viewed from a 76.5 cm distance, and subtended 3.75° visual angle. The emotional stimuli consisted of 32 (i.e., happy, angry, neutral) face stimuli from the NIMSTIM set (Tottenham et al., 2009). The two Landolt rings were presented at the locations of the face stimuli (see Figure 1B). All stimuli were randomized and counterbalanced; and each face appeared in all emotional conditions. We tracked fixation during the experimental paradigm with an eye-tracker (Eyelink1000, SR research, Arlington, USA) and all participants fixated well during the experiment.

5.2.2.3 Procedure. Testing took place during the hours of 9am and 6pm in the Laboratory for Social and Neural Systems Research (SNS-Lab) at the University of Zurich. Upon arrival, participants were instructed about the experiment and filled out an informed consent form. They completed the questionnaire measures prior to the laboratory session. Before starting the experiment, the chin rest and eye-tracker were adjusted and calibrated. After completion of the experimental task, participants were debriefed and received payment.

5.2.2.4. Data analysis. Two participants did not complete questionnaires due to language difficulties and were removed from the analysis. All dot probe data were analyzed following standard procedures (e.g., Mingtian et al., 2011): Trials with response times shorter than 200 ms (29 trials; < 1 %) and longer than 1200 ms (760 trials; 4.5 %) were removed (789 trials; 5.5 %).

AB scores were created by subtracting individual mean reaction time in congruent (i.e., probe behind emotional stimulus) from incongruent (i.e., probe behind neutral stimulus) trials. When responses are faster in congruent compared to incongruent trials, the AB score will be positive, indicating attention toward the congruent stimuli.

Reaction time (RT) differences between emotional and congruent/incongruent conditions were analyzed with a two-factorial ANOVA followed by paired t-tests. To predict self-reported trait resilience, we correlated individual AB with resilience scores and calculated a linear robust regression analysis in two steps, regressing the resilience score (RS-11) on both AB scores (positive and negative) in the first step, and adding the interaction between the two AB scores in the second step. In case of a significant interaction effect, we also conducted simple slope analyses (Aiken & West, 1991). Statistical analyses were computed using Stata 12 (StataCorp, 2011).

5.2.3 Results.

5.2.3.1 Descriptive group results. In a 2 x 2-factorial repeated measures ANOVA with the factors emotion (happy, angry) and congruency (congruent, incongruent), we found no main effects of emotion, $F(3, 42) = 0.42$, $p = .521$, or congruency, $F(3, 42) = 0.42$, $p = .420$, but a significant interaction between emotion and congruency, $F(3, 42) = 6.11$ $p = .018$. Follow up t-tests showed that responses to congruent happy (probe after happy face; $M = 742$ ms, $SD =$ 177 ms) were significantly slower than to incongruent happy trials (probe after neutral face; $M = 734$ ms, $SD = 169$ ms), $t(42) = 2.50$, $p = .017$. Congruent, $M = 737$ ms, $SD = 172$ ms, and incongruent, $M = 741$ ms, $SD = 175$ ms, angry trials were not significantly different, $t(42) = 1.60$, $p = .116$.

Happy and angry AB scores were significantly different, $t(42) = 2.48$, $p = .017$ (Happy: $M = -8.35$, $SD = 21.80$, range: -66.10 - 32.28; Angry: $M = 5.76$, $SD = 23.47$, range: -38.94 - 69.17), see Figure 1C. Importantly, there was considerable individual variability in AB scores, as necessary for the analysis of individual differences. Mean trait resilience in our sample was high, *M*= 60.88, *SD*= 9.14, range: 38 – 72.

5.2.3.2 Attentional Biases and Stress Resilience. As hypothesized, greater AB to happy, but not angry, faces was positively correlated with higher trait resilience, see Figure 1D-E. The first step of the robust regression showed that AB to happy faces significantly predicted higher trait resilience, b = .39, $t(38)$ = 2.61 p = .013, while AB to angry faces b = -.01, $t(38)$ = -0.10, p = .923 did not predict resilience, overall model: R^2 = .15, $F(2, 38)$ = 3.57, p = .038. When the interaction between AB toward happy and angry face stimuli was included into the model in step 2, neither AB to happy, b = .22, $t(37)$ = 1.40, p= .169, nor AB to angry faces, b = .12, $t(37)$ = 0.95, p = .347 alone predicted resilience, but the interaction between AB to happy and angry stimuli was significant, b = .38, $t(37)$ = 3.28 p = .002. The overall model was also significant in the second step of the regression, R^2 = .24, $F(2, 37)$ = 15.53, p < .001. To follow up the interaction, we regressed AB for happy stimuli on resilience in subgroups of high and low AB toward angry stimuli. As depicted in Figure 2, AB to happy stimuli predicted resilience in those with high AB to angry stimuli (B = 0.19, t= 2.86, p =.007), but not in those with low AB to angry stimuli, (B = -0.01, t = -0.02, p = .985).

Figure. 7. Modified Dot-Probe Task (A-B), Mean AB scores (C) and Pearson Correlations between AB Scores and Resilience (D-E)

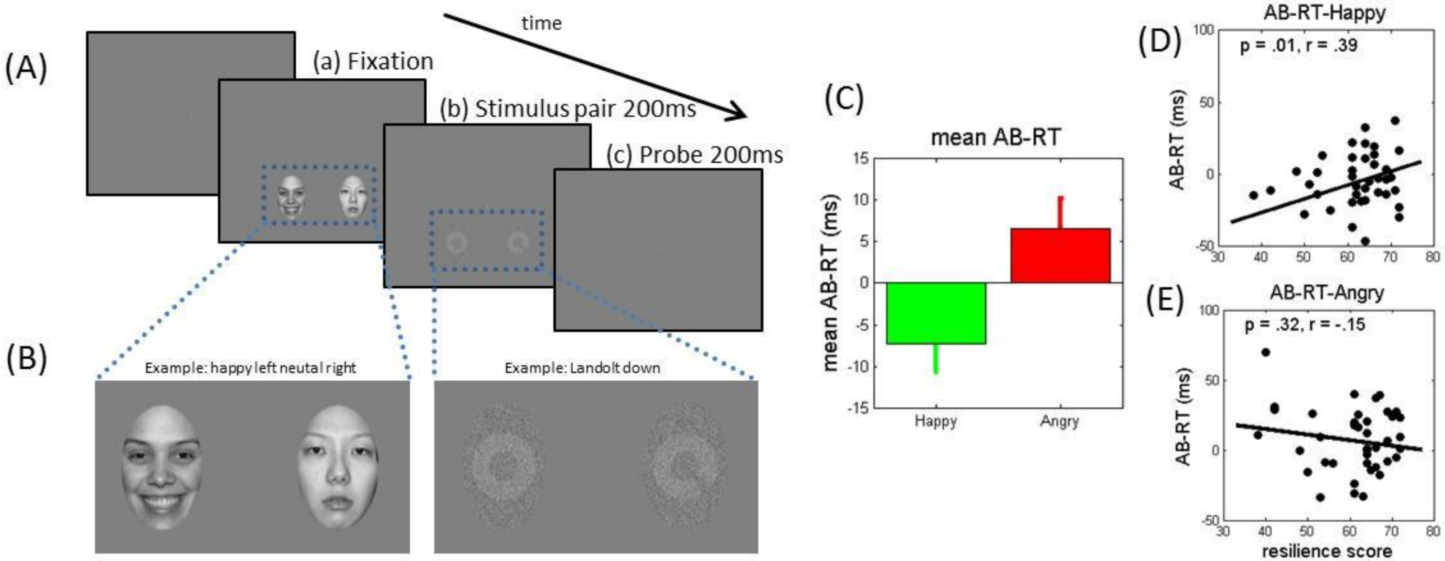


Figure. 1. A-B: Schematic structure of each trial of the dot probe task; C: Mean AB for happy and angry trials; D-E: Relationship between AB scores and stress resilience. AB-RT= reaction time-based attentional bias score, Resilience score= mean resilience score indexed with the Resilience Scale (Schumacher et al., 2005).

Figure. 8. Simple Slope Analyses Explaining Interaction Between AB Scores in Predicting Resilience

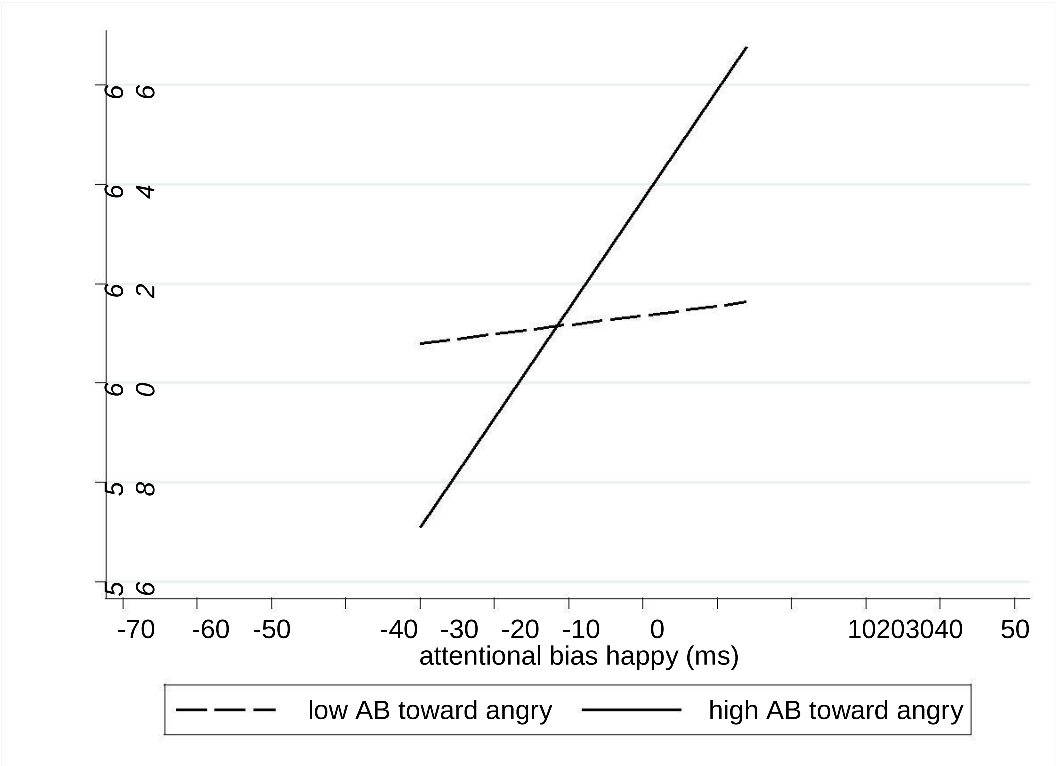


Figure 2. Low AB toward angry stimuli (dashed line) represents values 1 SD of below the mean, high AB toward angry stimuli (continuous line) represents values of 1 SD above the mean.

5.2.4 Discussion. The central aim of this study was to test whether an AB towards positive emotional material predicts resilience using a modified DPT. We hypothesized that AB toward happy, and possibly an AB away from angry face stimuli, would predict resilience and explored whether the two biases interact. In line with our hypothesis, we found that an AB toward happy, but not away from angry, face stimuli predicted greater self-reported stress resilience. An AB toward angry stimuli moderated this effect. These results provide preliminary evidence for a specific relationship between stress resilience and an AB toward happy face stimuli that is modulated by AB toward angry stimuli.

Overall, we found an effect for emotional valence as the group showed higher AB toward neutral and angry compared to happy faces. This is in accord with prior studies and the assumption that such an AB to positive stimuli is unlikely to overrule AB to negative or neutral stimuli in magnitude in healthy participants (e.g., Eldar & Bar-Haim, 2010). Negative material may generally have a stronger attentional draw than positive material (Fox et al., 2000). Importantly, however, we found considerable inter-individual variation in the extent to which participants' attention was drawn toward positive stimuli and thus in the magnitude in which an AB toward positive stimuli was expressed.

A first key finding was that individuals with higher AB toward positive stimuli reported greater resilience. This result extends earlier findings showing that AB toward positive stimuli is not only related to adaptive stress responses and less stress-related psychopathology (Johnson, 2009; Fox et al., 2012; Frewen et al., 2008; Joorman et al., 2007), but that it may promote stress-resilience. We found that the association was specific to an AB towards positive stimuli in our study, as there was no effect of an AB toward or away from negative stimuli on stress resilience. An AB toward positive stimuli may thus constitute a form of emotion regulation and thereby influence vulnerability to stress and psychopathology via the experience of positive emotion (Gross, 1998; Todd, Cunningham, Anderson, & Thompson, 2012). There is direct support for this assumption by experimental studies suggesting that AB toward positive stimuli is indeed related to positive mood (Tamir & Robinson, 2007). Frewen and colleagues (2008) put forward the explanation that individual differences in exposure to positive stimuli may lead to subsequent differences in the magnitude to which AB toward positive stimuli are expressed, with more exposure leading to more pronounced biases. AB training studies are in accord with this assumption, as participants trained to attend to positive stimuli reported lowered levels of post-training stress (Dandeneau et al., 2007) and stress related pathology (Li, Tan, Qian, & Liu, 2008). Individual differences exist in the extent to which an AB toward positive stimuli can be trained, however, and mitigated stress responses have been found only in those participants who indeed acquired an AB toward positive stimuli in such training studies (Johnson, 2009; Taylor et al., 2010).

A second key finding of our study was that an AB toward negative stimuli moderated the effect of an AB toward positive stimuli on resilience, in that an AB toward positive stimuli was predictive of resilience in those individuals who also endorsed an AB toward negative stimuli. There are two possible explanations for this finding. First, only for those endorsing a tendency to be sensitive to negative stimuli might an AB toward positive stimuli be an effective and necessary means of promoting resilience, whilst those without the bias towards negative material are less in need of this potentially protective process. Second, an AB toward threat has been shown to be protective in some groups (e.g., Bar-Haim et al. 2010; Wald et al. 2011), and it is conceivable that such a bias, in combination with a bias toward positive material, potentiates processes related to stress-resilience. More complex attentional mechanisms may be present in resilient individuals, and it is conceivable that the two interacting biases operate at different temporal lags (see also Onmis, Dadds & Bryant, 2011). Resilient individuals may initially orient and attend to threat and negative stimuli, but then attend to the processing of positive stimuli, which may serve as an adaptive and protective mechanism. The finding that some individuals do seem to be more prone to develop biases to both positive and negative material (Fox, Zougkou, Ridgewell, & Garner, 2011) further supports our finding of a mutual relationship between the biases. Further research will be necessary to disentangle possible mechanisms, including possible timelags at which these ABs operate, but our finding suggests that an AB toward positive stimuli may be protective, i.e., related to resilience, specifically in those individuals with a coexisting tendency to show automatic attentional responses to negative stimuli.

The current study is not without limitations. First, we used self-report questionnaires to measure trait resilience although multiple assessments of physiological and psychological functioning in naturalistic situations might be more reliable indices (Bonnanno et al., 2011). Second, the present sample comprised healthy control participants that were rather homogenous in trait resilience resulting in a possible ceiling effect. Third, our modified DPT indexed included a pre-threshold task to adjust the difficulty level for all participants, which may make our results less comparable with other DPT studies that exclude pre-adjustment. Fourth, we assessed attentional biases in the absence of threat or stressors. Indexing the same processes under conditions of stress might have rendered different results and should be investigated by future studies.

Taken together, our results show that increased attention to positive emotional stimuli predicts trait resilience and that this effect was specific to those individuals who endorse an AB to negative emotional stimuli. While we found an overall preference for processing neutral and angry above happy faces, individual differences in AB toward positive stimuli were predictive of trait resilience in our study. An AB toward positive stimuli may thus not constitute a "default" state endorsed by all individuals alike, but individual differences in such an AB are associated with enhanced ability to adapt to stressful situations. Further, our results suggest that AB toward positive and negative stimuli interact in influencing resilience, with an AB to positive stimuli being protective when an AB to negative stimuli is also present. These findings have important implications for the development of stress prevention programs and for improving treatment of stress-related disorders. Manipulating types of stimuli individuals attend to may help decrease vulnerability to stress-related psychopathology and increase resilience. Our results suggest that increasing the tendency to attend to emotionally positive stimuli could render individuals, specifically those who are also sensitive to negative emotional stimuli, more resilient.

5.3 Affective control predicts stress resilience and emotional reactivity to a laboratory stressor

5.3.1 Introduction. The ability to flexibly focus on task-relevant emotional stimuli and disregard emotional distracters, so called affective control, has been suggested to mediate emotion regulation to stressful events leading to individual differences in stress resilience (Ochsner & Gross, 2005; Troy & Mauss, 2011). Stimuli that are selectively attended to in stressful situations might elicit further reactions, such as cognitive appraisals, emotions and behavior, and attentional processes may thus modulate further stress reactions (Lazarus & Folkman 1984; Monroe & Kelly, 1997; Ochsner & Gross, 2005; Troy & Mauss, 2011). Some studies have indeed suggested that attentional control to neutral stimuli is related to decreased stress responses (Genet & Siemer, 2011; Liston, McEwen, & Casey, 2009). Liston at al. (2009) showed that chronic stress is associated with decline in attentional control measured with a switching task, and that the decline is reversed after termination of the stress (Liston et al., 2009). In contrast to these studies on neutral stimuli, the relationship between affective control, i.e. attentional control to emotional stimuli, and adaptive responses to stress and stress resilience is not well understood. One recent study reported that both affective and non-affective attentional flexibility were unique predictors of trait resilience (Genet & Siemer, 2011). However, this study used an affective flexibility task that does not directly assess affective control. The current study builds on these initial results and investigated whether higher affective control predicted trait resilience and emotional reactivity to a laboratory stressor.

Emotional stimuli are typically processed differently from neutral stimuli in the attentional process, as emotional information may be preferentially processed and might therefore interfere with processing of other types of stimuli (e.g., Ohman, Flykt, & Esteves, 2001; LeDoux, 2000). The interference by emotional stimuli is often adaptive, since such stimuli may carry important information about significant reward and threats (Reeck, LaBar, & Egner, 2012). However, if the individual cannot direct attention away from irrelevant emotional distracters, interference of emotional stimuli can be detrimental and lowered affective control has been linked to decreased ability to disengage from both distracting rewards and threats (Osseward, Qin, Van Marle, van Wingen, Fernandez, & Hermans, 2010). Recent evidence from imaging studies show that different neural routes are involved in regulating attentional control to emotional and neutral stimuli, with the rostral anterior cingulate inhibiting amygdale responses to irrelevant emotional stimuli, while a lateral prefrontal route is involved in regulating responses to distracting neutral stimuli (e.g., Egner, 2007; Etkin, Egner, & Kalisch, 2011).

Affective control, i.e. attentional control to such emotional stimuli, might be of particular importance in stressful situations because such situations are highly emotional (Sarason, Johson, & Siegel, 1978). Attentional control decreases in stressful situations, resulting in for instance a lowered ability for task switching in such situations (Liston et al., 2009; Plessow, Kirschbaum, & Goschke, 2011). Stress-related decreases in attentional control might also contribute to increased avoidance of relevant threat cues (Bar-Haim, Holoshitz, Eldar, Frenkel, Muller, et al., 2010). A few recent findings, using a dot-probe task assessing biased attention, indicate that preserved focus on both relevant threat and rewards in stressful situations is related to stress resilience (e.g., Bar-Haim et al., 2010; Wald, Shechner, Bitton, Holoshitz, Bar-Haim, et al., 2011; Vythilingham, Nelson, Scaramozza, Waldeck, Haylett, Soutwick et al., 2008). Moreover, studies indexing self-reported attentional control have linked decreased attentional control with non-adaptive coping, as for instance over-eating (Miller & Cohen, 2001; Osseward et al., 2010) and also with inability to disengage from internal negative stimuli such as in increased worry and intrusions (e.g., Hagenaars & Putman, 2011; Verwored, de Jong, & Wessel, 2008). Preserved attentional control in stressful situations, on the other hand, might be characteristic for resilient individuals (Charney & Southwick, 2010). These individuals endorse the ability to flexibly adapt to change and “bounce back” from adverse life experiences, including experience ranging from everyday problems to traumatic events (e.g., Ong, Bergeman, Bsiconti, & Wallance, 2006). According to Charney and Southwick (2010), resilient individual might be more likely to preserve focus on relevant stimuli in stressful situations and might use affective control to regulate their emotional response (Ochsner & Gross, 2005; Troy & Mauss, 2011).

The degree of exhibited attentional control depends on the level of conflict in the situational context (Botvinick, Braver, Barch, Carter, & Cohen, 2001), Congruency tasks, provide variations in conflict as proxies of such situational conflicts and have been suggested as reliable measures of e attentional control (e.g., Cohen, Dunbar, & McClelland, 1992; Egner, 2007). The Stroop task is a congruency task where the presentation of incongruent (i.e., conflicting facial and word) stimuli induces conflict (e.g., Egner, 2007; Monti, Weintraub, & Egner, 2010). Findings with Stroop tasks typically show increased interference reduction by distracters in trials following incongruent trials (Botvinick et al., 2001; Carter, Macdonald, Botvinick, Ross, Stenger, Noll, & Cohen, 2001; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Logan & Zbrodoff, 1979; Monti et al., 2010). These so called congruency sequence-effects have been put forth as a direct measure of regulation of attentional control in response to conflict (Botvinick et al., 2001; Egner, 2007; Gratton, Coles, & Donchin, 1992). From this perspective, attentional control involves both detection of conflict and ongoing adjustment to the level of conflict (Botvinick et al., 2001; Monti et al., 2010).

In the current study, we measured affective control (i.e., conflict adaptation to emotional stimuli) with a modified emotional Stroop task (e.g., Etkin et al., 2006; Monti et al., 2010). Conflict adaptation scores reflect the interaction between the previous and current trial on performance, with higher values reflecting higher affective control (Etkin et al., 2006; Monti et al., 2010). Conflict adaptation scores acknowledge that the typical findings from current trail congruency (i.e., slower responses to incongruent stimuli) are modified by the congruency in the previous trial. Typically, the congruency effect on the current trials is mitigated by a previous incongruent trial, reflecting higher exhibition following conflict (Gratton et al., 1992; Egner, 2007; Monti et al., 2010).

Taken together, recent theory and empirical studies suggest that affective control constitutes an important aspect of resilience by mediating emotional responses in stressful situations (Gross & Ochsner, 2005; Troy & Mauss, 2011). However, the nature of attentional control has previously often been measured with self-report assessments (e.g., Hagenaars & Putman, 2011; Verwoered, et al., 2008). The present studies expand on these results and indexed affective control with a behavioral task (Egner, 2007). We assessed affective control in the context of a cross-sectional study using self-report questionnaires of trait resilience. Moreover, we examined the association between attentional control and emotional reactivity to a laboratory stressor. The main aims of the current study were twofold, to investigate whether affective control was associated with (i) self-reported trait resilience, and (ii) emotional responses to a laboratory stressor, i.e., less decrease in positive mood, as well as less distress in response to the laboratory stressor. Such results would be in line with theoretical suggestions that higher affective control predicts better emotion regulation leading to stress resilience (Gross & Ochsner, 2005; Troy & Mauss, 2011)..

5.3.1.1 The present studies. The behavioral task used in the current studies has been established as a measure of affective control and conflict adaptation (e.g., Etkin et al., 2006; Monti et al., 2010). The experimental task used in both studies included the presentation of emotional face stimuli with an overlaid emotional word, and participants had to indicate the emotional expression of the face (e.g., fearful, happy). The word can be either congruent or incongruent with the facial expression. Trials are shown successively, with each trial following either a congruent or incongruent previous trial. Response time in trials following an incongruent trial is typically shorter, reflecting higher affective control and better conflict adaptation (e,g., Monti et al., 2010).

Study 1

In the first study, we investigated the association between affective control and self-reported trait stress resilience.

5.3.2 Method.

5.3.2.1 Participants. Forty-eight healthy students (mean age 26.15 years, *SD*= 5.75; 32 (65.31%) women, 17 (34.69%) men) participated against a monetary compensation of 25 CHF (27 USD). Participants were screened for previous or current psychiatric illness. All participants had normal or corrected-to-normal vision. They gave informed consent and the local ethic board approved the study.

5.3.2.2 Measures.

5.3.2.2.1 Affective control task. The experimental task, i.e. a modified emotional Stroop task, has been used extensively to measure conflict adaptation (Etkin et al., 2006; Monti et al., 2010). As shown in figure 1, each trial included (1) the presentation of a central fixation cross for 1000 ms, (2) the presentation of an emotional face (i.e., happy or sad) with an overlaid emotional word (i.e., happy or sad) for 1000 ms, and (3) an intermediate trial period of 3000 ms. Participants were asked to indicate whether the facial expression of the stimuli was happy or fearful, and thus had to disregard the emotional word, and to respond by pressing a key as fast and accurate as possible. After a short practice, participants completed 100 trials (50 congruent, 50 incongruent). The task session lasted for around 9 minutes. Similarly as in other studies using the experimental task (see e.g., Reeck et al., 2012), the semantic meaning of the words that are laid over the face stimuli can be either congruent or incongruent with the facial expression of the face stimuli. In the current study, the congruent conditions consisted of either happy face- happy word or fearful face- fear word, and the incongruent conditions consisted of happy face – fear word, or fearful face – happy word. Stimuli presentation was randomized and counterbalanced between participants.

Figure 9. Stimuli and Schematic Trial of the Emotional Stroop task used in both Studies

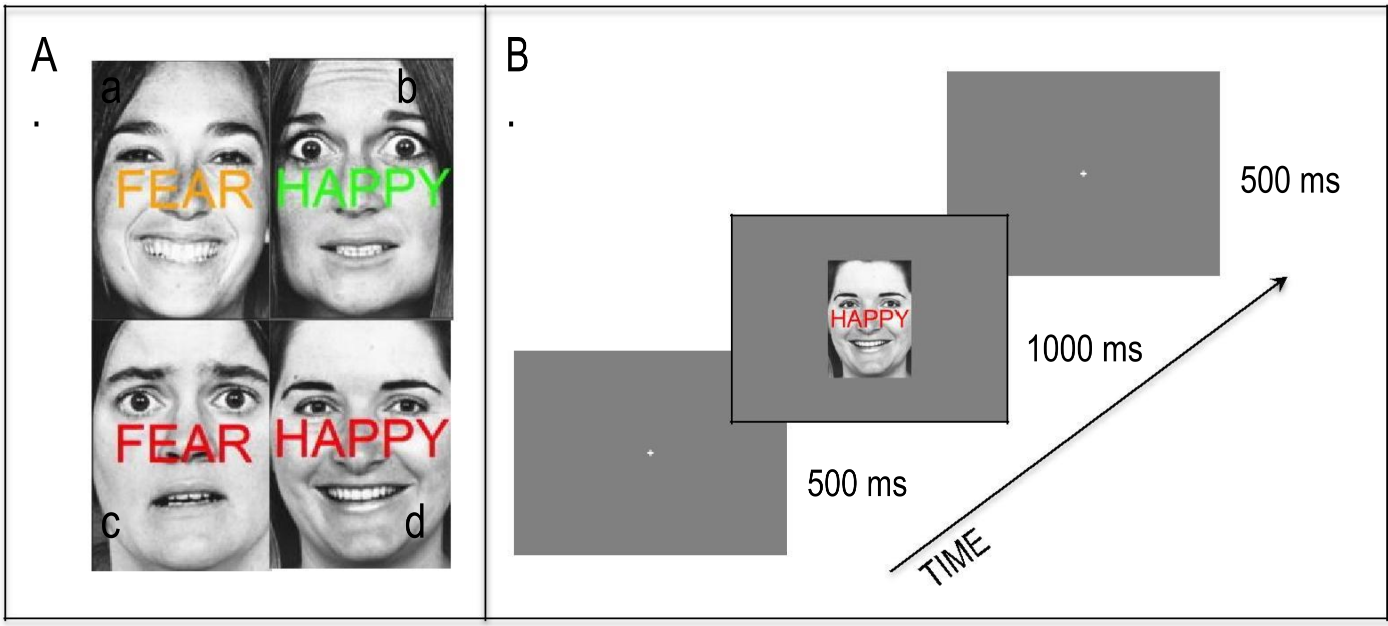


Figure. 1. A: Example stimuli in different emotional conditions; a) incongruent happy stimuli, b) incongruent fear stimuli, c) congruent fear stimuli, d) congruent happy stimuli; B: Schematic trial.

Following Etkin et al. (2006), we constructed individual RT scores by creating a mean sum score for congruent trials following congruent trials (CC), incongruent trials following congruent trials (CI), incongruent trials following incongruent trials (II) and congruent trails following incongruent trails (IC). Table 1 show means and SDs of RT scores. We then constructed individual conflict adaptation scores using the following formula [(CI-CC) – (II-CI)]. Conflict adaptation scores reflect the interaction between previous and current trial on the performance, with higher values reflecting better conflict adaptation (Monti et al., 2010).

Black- and white face stimuli from the Ekman set of facial expressions were used as stimuli (Ekman & Friesen, 1976), depicting eight female and six male individuals showing happy or fearful expressions with either open or closed mouth. Emotional words, either “happy” or “fear”, were laid over the face stimuli in a central position, resulting in two conditions; emotional face (happy, fearful) x word stimuli (happy, fear). The stimuli were presented on a computer monitor (36.5 cm wide and 27.5 cm high) using a Windows PC computer and Cogent 2000 (http://visilab.ucl.ac.uk/cogent_2000.php) running in MATLAB (MathWorks, Natick, MA, USA). A chin rest was used to ensure a distance from the screen of
76.5 cm

5.3.2.2.1 Self-reported stress resilience. The Resilience Scale (RS-11; Wagnild & Young, 1993) was used to index trait stress resilience. The RS-11 measures resilience as a personality trait and includes items covering ratings of personal competence (e.g., self confidence, independence) and acceptance of self and life (e.g., flexibility, tolerance). Each of the items is answered using a scale ranging from 1 (“No, I don’t agree“) to 7 (“Yes, I totally agree”). A sum score ranging from 11 to 77 is obtained by adding up the 11 items. The RS-11 has high internal consistency, Cronbach α= .91 (Wagnild & Young, 1993), in the present sample Cronbach α= .80.

5.3.2.3 Procedure. The experiment took place in the Laboratory for Social and Neural Systems Research (SNS-Lab) at the University of Zurich between the hours of 9am and 6pm. Before the laboratory session, the participants filled in questionnaires, including the resilience questionnaire. For performing the attentional control task, a chin rest was adjusted and calibrated before starting the experiment and participants kept their head on the rest whilst completing the task. Upon finishing of the experimental task, participants received payment and were debriefed.

5.3.2.4 Analysis. Data was analyzed using Stata (Stata Inc). Regarding response time (RT) scores, in accord with earlier analyses (Monti et al., 2010; Reeck et al., 2012), incorrect responses and outliers were excluded, resulting in exclusion of less than 1% of the trials.

Outliers were defined as values 2 standard deviations below or over the grand mean of each individual.

We first computed a repeated 2 x 2 factorial ANOVA, with the within-subject factors of congruency in the current trial (congruent, incongruent), and congruency in the previous trial (congruent, incongruent). Results were followed up with paired t-tests. The relationship between RT scores and trait resilience was analyzed using robust regression analyses. Alpha levels were set to 0.05.

5.3.3 Results.

***5.3.3.1 Descriptive group results*.** A 2 x 2-factorial repeated measures ANOVA with the factors congruency in current trial (congruent, incongruent) and congruency in the previous trial (congruent, incongruent), we found a significant effect of congruency in the current trial, $F(1, 40)= 43.35$, $p < .000$, and congruency in the previous trail, $F(1, 40)= 7.10$, $p= .007$, and a significant interaction between congruency in the current and previous trial, $F(1, 40)= 6.33$ $p= .011$. Follow up t-tests showed that responses to current congruent (face and word stimuli congruent; M= 663.91 ms, SD= 212.46 ms) were significantly shorter than to current incongruent trials (face and word stimuli incongruent; M= 704.50 ms, SD= 243.50 ms), $t(47) = -5.85$, $p<.000$. Congruent previous trail, M= 675.06 ms, SD= 225.20 ms were significantly shorter than incongruent previous trials, M= 692.01 ms, SD= 226.68 ms, $t(47)= -2.47$, $p= .013$. CC scores were significantly different from CI, IC, and II scores (CC= CI $t(46)=-7.65$, $p<.000$; CC=II, $t(46)=-4.04$, $p=.000$; CC=IC, $t(46)=-4.60$, $p<.000$). IC was significantly difference from CI scores, $t(46)=-2.53$, $p=.015$. No other significant differences were found for congruency and incongruency scores (IC=II, $t(46)=0.05$, $p=.959$; II=CI, $t(46)=-1-11$, $p=.273$).

5.3.3.2 Affective Control and Trait Stress Resilience. As hypothesized, greater conflict adaptation was positively correlated with higher trait resilience, see figure 2. As can be seen in table 3, a robust regression showed that greater conflict adaptation significantly predicted higher trait resilience.

Table 2. Affective control predicts trait stress resilience (study 1)

Predictor	B	Std. Error	*t*	*B*
Affective control	.03	.01	.04	.27*

Note: N= 45*;* Stress resilience was measured with the Stress Resilience Scale (Wagnild & Young, 1993). Model: $F(2, 42)=3.63$, $p= .035$.

*p< .05.93

Study 2

In the second study, we investigated the association between higher conflict adaptation and emotion reactivity to a laboratory stressor.

5.3.3 Method.

***5.3.3.1 Participants*.** Sixty-one healthy female volunteers participated (mean age 25.11 years, *SD*= 5.32) against a monetary compensation of 50 CHF (56 USD) or 3 credit points. A telephone screening of previous or current psychiatric illness and previous direct or indirect exposure to interpersonal violence was conducted with participants prior to coming to the laboratory to minimize the re-traumatization risk. All participants had normal or corrected-to-normal vision. They gave informed consent and the local ethic board had approved the study.

5.3.3.2 Measures and material.

5.3.3.2.1 Affective control task. The experimental task and setup was the same as the one used in study 1.

5.3.3.2.2 Materials. The stimuli in the behavioral task were described for study 1. The stimuli were presented on a computer monitor (36 x 24 cm^2) using a Packard Bell laptop and Cogent 2000 (http://visilab.ucl.ac.uk/cogent_2000.php) running in MATLAB (MathWorks, Natick, MA, USA).

5.3.3.2.3 Laboratory stressor. The film sequence was taken from the screen movie “Irrevèrsible” directed by Gaspar Noe (2002). The used sequence was approximately 12 minutes long and showed a young woman walking through an underpass and then being brutally raped. The film sequence has been used and established as a potent stressor in previous studies that led to analogue symptoms of posttraumatic stress disorder, such as intrusive memories (e.g., Weidmann, Conradi, Gröger, Fehm und Fydrich, 2009).

5.3.3.2.4 Emotional reactivity. Emotional reactivity was measured prior and following the stressful film sequences with two scales (i) the short version of the Multidimensional Mood State Questionnaire (MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997) and (ii) the Self-Assessment Manikin Scale measuring affective responses (SAM; Bradley & Lang, 1994). In addition, we analyzed the mood subscale of the MDBF. Similar as in prior studies emotional and affective reactivity scores were constructed by subtracting mood and affect ratings from after the stressor from those prior to the stressor. This resulted in a mood reactivity score (i.e., MDBFpre - MDBFpost) and an affective reactivity score (i.e., SAMpre-SAMpost). The mean emotional reactivity scores are presented in table 4.

5.3.3.2.3.1 Multidimensional Mood State Questionnaire. The Multidimensional Mood State Questionnaire indexes psychological state and includes items related to mood, alertness and calmness. For the present study, both the sum score of the MDBF and the mood subscale were used. The short version of the MDBF comprises 12 items ranging from 1 ("Not at all") to 5 ("very much") that are added up to a sum score. The mood subscale consists of 4 items asking participants to indicate how content, good, bad or uncomfortable they feel at the moment. Answers are added up to an overall sum score indexing mood, with higher scores reflecting better mood. The MDBF has shown high internal consistency scores, Cronbach $\alpha = .73$ to $\alpha = .89$ (Steyer et al., 1997) and in our sample, Cronbach α was .79 prior and .91 following the film sequence.

5.3.3.3.3.2 The Self-Assessment Manikin Scale. (Bradley & Lang, 1994) is a non-verbal self-report assessment that measures affective response to stimuli. Participants indicate their current affect by choosing one of nine different animated faces ranging from 1 (happy face) to 9 (unhappy face) on the valence scale. Higher scores indicate more negative affect.

5.3.3.4 Gaze avoidance. Participants indicated the degree to which they deliberately directed their gaze away from the film on a 5-point scale from 1("Not at all") to 5 ("Very frequently").

5.3.3.3 Procedure. The experiment took place in a standard laboratory at the University of Zurich during the hours of 11 am and 3 pm. Upon arrival the participants were informed about the nature of the film sequence and gave their informed content. Participants then completed the conflict adaptation task (i.e., the modified emotional Stroop task). Thereafter, they viewed the film sequence in a dark room. Two participants found the film sequence too stressful and terminated the viewing. All participants filled out mood questionnaires including the MDBF and the SAM mood scales before and after the film sequence. Following the film sequence, they also filled out a demographic and general information questionnaire.

Debriefing session took place at from a week after the laboratory session. In the session, participants were debriefed, given the possibility to ask questions and reimbursed for their participation. Finally, participants were reassured that a registered clinical psychologist could provide help in case of disturbances triggered by the film.

5.3.3.4 Analysis. Data was analyzed as described in study 1. The relationship between RT scores and emotional reactivity to the stressful film sequence was analyzed with correlations and in a robust regression.

5.3.4 Results.

5.3.4.1 Descriptive group results. A 2 x 2-factorial repeated measures ANOVA with the factors congruency in current trial (congruent, incongruent) and congruency in the previous trial (congruent, incongruent), we found a significant effect of congruency in the current trial, $F(1, 53)= 12.87$, $p< .000$, and congruency in the previous trail, $F(1, 53)=6.62$, $p= .010$. Follow up t-tests showed that responses to current congruent (face and word stimuli congruent; $M= 823.60$ ms, $SD=453.38$ ms) were significantly shorter than to current incongruent trials (face and word stimuli incongruent; $M= 855.44$ ms, $SD= 369.56$ ms), $t(60) = -2.99$, $p= .003$. Congruent previous trail, $M= 828.69$ ms, $SD= 411.51$ ms, and incongruent trial, $M= 850.33$ ms, $SD= 422.72$ ms, were significantly different, $t(60) = -2.03$, $p= 042$. CC scores were significantly different from CI, IC, and II scores (CC= CI $t(60)=-3.17$, $p=.002$; CC=II, t(60)=-4.67, $p<.000$; CC=IC, $t(60)=-5.58$, $p<.000$). No other significant differences were found for congruency and incongruency scores (IC= CI $t(60)=-0.13$, $p=.896$; IC=II, $t(60)=0.74$, $p=.462$; II=CI, $t(60)=0.72$, $p=.474$).

***5.3.4.2 Affective control and emotional reactivity*.** There were significant correlations between conflict adaptation, emotional reactivity (indexed by the MDBF, SAM) and gaze avoidance, as shown in table 4. We conducted separate robust regression for the two emotional reactivity measures, controlling for gaze avoidance during the stressful film sequence. In addition, we conducted a regression for the whole MDBF scale, thus predicting the change in psychological state in response to the stressor with affective control.

Figure 10. Correlation Between Affective Control and (A) Trait Resilience, (B) Mood Reactivity to Stress and (C) Affective Reactivity to Stress

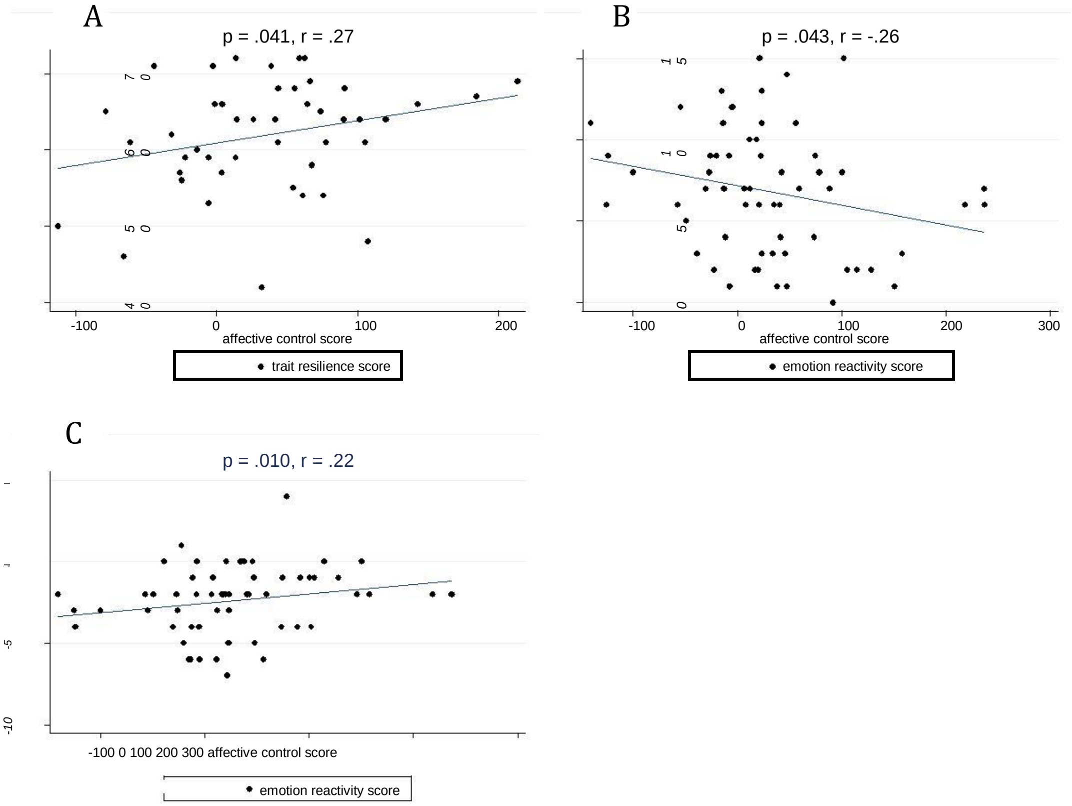


Figure. 2. Correlations between individual affective control scores and (A) self-rated trait stress resilience scores (study 1); (B) mood reactivity (study 2); affective reactivity (study 2).

Table 3. Descriptive statistics and Spearman correlations between key variables (study 2)

	M (*SD*)-	1	2	3
1.Mood reactivity[1]	6.85(3.87)			
2. Affective reactivity[2]	-2.37 (2.05)	-.73***		
3. Affective control	31.56(77.98)	-.26*	.27*	
4. Gaze avoidance	0.24(0.43)	.26*	-.25	-.07

Note: *N*= 61; [1] Emotional reactivity was measured with the Multidimensional Mood State Questionnaire (Steyer et al., 1997) prior and following the film sequence; [2] Measurement of emotional reactivity with the Self Assessment Manikin Scale (Bradley & Lang, 1994).

*p< .05, **p<.01, ***p<.001.

5.3.4.2.1 Baseline and post-stress mood and affect. Neither affective control, β =.06, $t(58) = 0.39$ $p = .699$., nor gaze avoidance, $\beta = -.11$, $t(58) = -0.85$ $p = .399$, were related with pre-stressor mood state (i.e., MDBF full scale) $R^2 = .01$, $F(2, 58) = 0.41$, $p = .664$. Higher affective control did not significantly predict psychological state after the stressor, $\beta = .18$, $t(58) = 1.80$, $p = .076$., but gaze avoidance, ,$\beta = -.25$, $t(58) = -2.30$, $p = .025$., predicted better affective state, $R^2 = .10$, $F(2, 58) = 3.73$, $p = .030$. As displayed in table 5, neither affective control nor gaze avoidance was significantly related to emotional state before the laboratory stressor. Emotional state post-stressor significantly predicted by gaze avoidance, with more gaze avoidance predicting higher negative mood ratings. Higher affective control predicted better mood post-stressor at trend level, $p = .090$. Higher affective control, but not gaze avoidance, predicted better affective state (i.e., SAM scale pre-post) post- stressor

5.3.4.2.2 Mood and affect reactivity. For the mood state (i.e., whole MDBF scale) higher affective control predicted less negative change in psychological state after, compared with before, the stressor, $\beta = -.21$, $t(58) = -2.57$, $p = .013$., while lower gaze avoidance did not significantly predicted change in psychological state, $\beta = .24$, $t(58) = 1.69$, $p = .097$, and the model was significant, $R^2 = .11$, $F(2, 58) = 4.76$, $p = .012$.

As seen in table 5, higher affective control predicted decreased mood reactivity (i.e., MDBF mood subscale prior – MDBF mood subscale mood after the stressor) in response to the stressful film sequence. Higher affective control and lower gaze avoidance also predicted affective reactivity in response to the laboratory stressor, i.e. less increased negative affect.

Table 4. Affective control and gaze avoidance predicts emotional reactivity in response to a laboratory stressor (study 2)

Predictor	Pre-stressor				Post- stressor				Reactivity			
Model 1: Predicting mood												
	B	Std.error	t	*β*	B	Std.error	t	*B*	B	Std.error	t	*B*
Affective control	.00	.00	0.44	.05	.01	.01	1.68	.20	-.01	.01	-2.25	-.22*
Gaze avoidance	-.09	.52	-0.18	-.02	-2.43	1.05	-2.30	-.25*	2.46	1.24	-1.99	.27*
Model 2: Predicting affect												
	B	Std.error	t	*β*	B	Std.error	t	*β*	B	Std.error	t	*B*
Affective control	-.00	.01	-0.10	-.02	-.01	0.00	-2.01	.23*	0.01	.01	2.47	.20*
Gaze avoidance	-.15	.38	-0.39	-.06	0.60	0.60	1.64	.23	-1.14	0.72	-1.57	-.23*

Note: Dependent variable: Emotional reactivity: *N*= 61*;* Emotion before stressor: $F(2, 58)=0.10$, $p= .901$, R2=.00; Emotion after stressor: $F(2, 58)=3.67$, $p= .031$, R2=.11; Delta emotion: $F(2, 57)=3.75$, $p= .029$, R2=.13. Gaze avoidance was measured by a questionnaire after the viewing of the film sequence. Emotional reactivity was measured with the difference score (post- subtracted from pre-stressor scores) on the Multidimensional Mood State Questionnaire (MDBF; Steyer et al., 1997).

Affect before stressor: $F(2, 58)=0.08$, $p= .921$, R2=.00; Affect after stressor: $F(2, 58)=0.05$, $p= .049$, R2=.11; Delta affect: $F(2, 58)=034$, $p= .034$, R2=.10. Affect reactivity was measured with the difference score (post- subtracted from pre-stressor scores) on the Self-Assessment Manikin Scale (SAM; Bradley & Lang, 1994). *p< .05.

5.3.5 Discussion. The current studies tested the hypothesis that higher affective control results in more adaptive stress regulation by examining the role of individual differences in affective control in predicting stress resilience. We found that higher affective control predicted trait resilience and more adaptive emotional reactivity in response to a laboratory stressor. These results are in line with recent theoretical accounts proposing that better affective control may lead to resilience through increasing adaptive emotion regulation strategies (Gross & Ochsner, 2005; Troy & Mauss, 2011).

Individuals with higher affective control reported higher trait resilience and lower emotional reactivity to a stressor in the present study. A recent study reported that higher attentional flexibility to both neutral and emotional stimuli predicted trait resilience (Genet & Siemer, 2011). However, these authors used a behavioral task (i.e., attentional flexibility task), which does not directly assess affective control, and did not measure emotional responses to stressors. Our results are also in line with findings that lower attentional control is associated with increased worry and intrusions (e.g., Hagenaars & Putman, 2011; Verwored et al., 2008), however, in these studies attentional control was indexed with self-report measures (e.g., Hagenaars & Putman, 2011; Verwored et al., 2008). Finally, a previous study reported that higher perceived stress in response to chronic stress was related with lowered attentional control (Gray et al., 2010). However, this study used a switching task to assess attentional control (Gray et al., 2009), and affective control is likely to relate differently to stress resilience. These prior studies also did not index resilience and emotion reactivity. Future studies should investigate the mechanisms governing attentional and affective control in relation to resilience.

What attentional mechanisms may promote stress resilience? Recent theoretical suggestions point to that higher affective control might in fact lead to better emotion regulation that in turn mediates resilience (Troy & Mauss, 2011). The reasons for the improvement of emotion regulation with higher affective control might be that higher control enables stronger top-down regulation of attention to emotional stimuli (e.g., Bishop, 2009; Foster et al., 2013). This type of early attentional regulation is ongoing during a stressful event, and might steer further cognitive, emotional and behavioral reactions (Ehlers & Clark, 2000; Matsumo & Ekman, 2010; Scherer & Ceschi, 1997). Higher affective control thus improves emotion regulation through better control of the stimuli input (e.g., Troy & Mauss, 2011). Appraisals reflect the perception of a situation, and it has been found that for instance positive appraisals about a situations lead to better outcome (Janis, 1983; Skinner & Brewer, 2002; Totterdell & Parkinson, 1999) and that coping in stressful situations are congruent with the appraisals about that situation (Zakowski, Hall, Cousino-Klein, & Baum, 2001). Individual differences in attentional control might thus influences stress reactions through enabling flexible shifts in focus of what stimuli are processed, and thereby how a situation is perceived. Such shifts might for instance enable termination of attention to emotional distracters or steering of attention toward stimuli that promote mitigation of stress responses, such as attention to positive stimuli (e.g., Totterdell & Parkinson, 1999; Troy & Mauss, 2011). Taken together, since stimuli that are attended evoke stronger responses, the control of emotion through processes such as affective control is important for an adaptive stress response (Ochsner & Gross, 2005). However, the interplay between selective attention, emotions and behavior is likely to be influenced by additional factors, such as working memory capacity and learned biases. Future studies are needed to clarify the relationship between affective control, appraisals and behavior.

The current study is not without limitations. First, we used a behavioral task to measure affective control that has been previously used in studies measuring affective control (Etkin et al., 2007; Monti et al., 2010). Affective control is measured by indexing individual differences in congruency sequence effects. However, a few earlier studies have found that feature integration (i.e., episodic memory effects on stimuli-response associations) explain a part of such effects (e.g., Egner, 2007; Hommel, Proctor, & Vu, 2004). Although our results favored the conflict adaptation model, we did not account for possible feature integration effects, as we would have needed substantially larger data set to do so. Future studies could take such effects into account. Second, we found that higher affective control predicted trait resilience and emotional reactivity to a laboratory stressor. However, the goodness of fit of the regression models was moderate, indicating that other factors influence resilience. Such factors might include aspects of cognitive change, such as appraisals and working memory capacity (Goeschke, 2013). Third, we measured trait resilience and emotional reactivity with well-validated self-rating questionnaires that are easy to administer (Steyer et al., 1997; Wagnild & Young, 1993). Several other possibilities of measurement could be considered, and longitudinal psychological and physiological responses to stressful events might have been a more accurate measurement of resilience (Bonnanno, Mancini & Westphal, 2011). Further, we assumed that higher emotional reactivity is related with lower resilience. Longitudinal measures would have directly assessed this assumption. However, prior research has shown that higher emotional reactivity to stressors (i.e., more negative emotions) predict worse functioning and more stress-related disorder as long as 10 years after the measurement of reactivity (e.g., Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013). Finally, it may be questioned whether our results can be generalized to other populations exposed to stress. The findings should be replicated in other populations in order to draw firm conclusions.

Our results have clinical implications. Deficits in attentional control are common in several psychopathologies including depression, anxiety and post-traumatic stress disorder (American Psychiatric Association, 2000; Liston et al., 2009). Although knowledge about such deficits is crucial, resilience research in healthy and high resilient populations has been sought for as a mean of establishing guidelines for clinical intervention (e.g., Yiend, 2010). Increased knowledge about mechanisms governing affective control leading to more resilient outcomes could guide both prevention and treatment of stress-related disorder. Based on the present results, increasing affective control could be a target for improving resilience in stress-exposed populations. Our findings indicate that training to increase affective control to emotional stimuli might serve as stress prevention and treatment of stress-related disorders. Interestingly, computerized training has recently been shown to increase affective control (Schweizer, Grahn, Hampshire, Moobs, & Dalgleish, 2013) and such interventions could be applied as stress prevention.

6. Discussion

The presented studies used two standardized behavioral tasks to assess individual differences in biased attention to emotional stimuli and affective control together with measures of resilience. The main hypotheses were that higher biased attention to positive stimuli, as well as higher affective control would be related with higher resilience. Our results (referring to all studies) were hypothesis conform, showing that higher resilience were related to higher biased attention to positive stimuli and higher affective control. In addition, we found evidence (biased attention study) for that the higher biased attention to positive stimuli was only predictive of resilience in individuals with an additional AB to negative stimuli.

The results are discussed separately for the two presented articles below, starting with the finding for biased attention (6.1) followed by the finding for affective control (6.2), thereafter methodological considerations for both studies are provided (6.3), and finally concluding remarks and future directions are outlined (6.4).

6.1 Biased attention to positive stimuli and trait resilience

We investigated biased attention to emotional stimuli with a standardized behavioral task (i.e., modified dot-probe task) together with self-reports of trait resilience in 43 healthy participants. The result showed that higher biased attention to positive stimuli was related with higher trait resilience. However, biased attention to positive stimuli was predictive of resilience only in those participants that had an additional bias to negative stimuli.

Our main finding, that more attention to positive stimuli predict resilience, is in line with recently theory suggesting that biased attention to positive stimuli constitute a type of early emotion regulation in stressful situations (Todd et al., 2012). According to this account, more biased attention to positive stimuli might increase experiences of positive emotion and thereby lead to higher resilience. This is indirectly supported by earlier evidence, showing that increasing positive mood leads higher biased attention to positive stimuli (Tamir &

Robinson, 2007). However, it should be noted that this study did not report whether biased attention had an impact on emotion (Tamir & Robinson, 2007). While several earlier studies have found a relation between lower biased attention to positive stimuli and higher rates of stress-related psychopathology, such as anxiety (Frewen et al., 2007) and vulnerability to depression (Joorman & Gotlib, 2010) our study is the first to establish an association between biased attention to positive stimuli and trait resilience.

We also found that biased attention to positive stimuli was predictive of resilience only in those participants that had an additional bias to negative stimuli. This result together with earlier research suggest that that increased biased attention might be more beneficial in individuals that tend to have more negative emotions and cognitions (for instance due to genetic vulnerability). Our result also suggests that biased attention to positive stimuli might be of higher importance in stressful situation, as such situations are associated with more negativity, such as increased negative emotions and cognitions (Bar-Haim et al., 2007).

Biased attention to positive stimuli might protect the individual from “tear and wear” in stressful situations, by breaking of prolonged stress-reactions.

Our results also suggest that higher attention to positive stimuli is not beneficial in individuals that avoid negative stimuli. This finding is indirectly supported by earlier evidence. For instance, if attention to positive stimuli functions as avoidance of facing real problems it is likely to have only short time benefits, and perhaps lead to increased distress later on (e.g., Kross & Ayduk, 2008). It has been found that avoidance as coping is related to higher risk of developing depression later on (Felsten, 2002: Holahan, Moos, Holahan, Brennan, & Shuttle, 2005; Troy & Mauss, 2013). Rather than a single-minded focus on only positive stimuli, a relative larger amount of attention to positive stimuli, together with selective attention to concrete and real challenges might contribute to resilience (Charney & Southwick, 2012). Thus, an adaptive interplay between biased attention to stressor-related stimuli together with biased attention to positive stimuli might constitute a “resilient” profile in stressful situations.

It is disputed whether higher biased attention reflects susceptibility to develop both positive and negative environmental influences. The susceptibility model suggests that some individuals are more prone to develop biases to all types of stimuli (Pluess & Belsky, 2013). The model is indirectly supported by evidence showing that some individuals exhibit more malleability to ABM interventions (Fox, Zougkou, Ridgewell, & Garner, 2011). Further support for this model has been found in a large prospective study with American soldiers conducting a dot probe task (negative vs neutral stimuli) before and after military deployment (Disner, Beevers, Lee, Ferrell, Hariri, & Telch, 2013). Soldiers that developed a strong bias to negative stimuli following deployment had significantly more stress related symptomatic (Disner et al., 2013). However, this study did not include positive stimuli, making it hard to draw conclusions on whether the result indicates a plasticity to develop biases to positive stimuli as well.

In line with preliminary findings pertaining to plasticity in biased attention, a few studies have shown that only individual that develop biases to positive stimuli (i.e., higher post-ABM level of the bias) show transfer effects to emotional and behavioral measures (e.g., Johnson, 2009: Taylor et al., 2010). If larger biases are an expression of plasticity, information about an individual’s susceptibility level might provide important clinical information. For instance, individuals high on plasticity might be more likely to benefit from therapeutic interventions (Harmer & Cowen, 2013).

We found that biased attention to positive stimuli is related with higher stress resilience. Our finding might have important clinical implications. Training to attend positive stimuli was found in one study to lead to lower stress reactivity (i.e., cortisol, negative emotion) as well as better performance (i.e., self-esteem, sales) to work related stress

(Dandeneau et al., 2007). This and other similar findings (Li et al., 2008) indicate that training to increase biased attention to might stress preventive effects. Future research is needed how ABM trainings to increase biased attention to positive stimuli might be used in prevention and treatment of stress-related disorder.

6.2 Affective control predicts stress resilience

In two studies healthy participants completed a behavioral task indexing affective control together with measures of resilience. In the first (*N*=48) study, resilience was measured with a self-rating questionnaire assessing trait resilience. In the second study (*N*=61), the female participants completed mood and affect questionnaires prior and after a standardized laboratory stressor. The result showed that higher affective control was related with higher trait resilience in study one and with more adaptive emotion reactivity in study two. The results are in accord with recent theoretical accounts suggesting that higher affective control leads to higher stress resilience over better emotion regulation (Ochnser & Gross, 2005; Troy & Mauss, 2011).

Our results are in line and expand on earlier evidence. To the best of our knowledge, the presented study was the first to directly assess if affective control leads to higher stress resilience. However, prior evidence has shown that attentional control is lowered both during acute and chronic stress (Gray et al., 2009; Plessow et al., 2011a, Plessow et a., 2011b). However, these studies assessed attentional (i.e., attention to neutral stimuli), and not affective (i.e., control to emotional stimuli), control. Attentional and affective control might be differently related with resilience, as they seem to be governed by distinct neural routes (Egner, 2007). Further, one recent study found that higher affective flexibility to both neutral and emotional stimuli was related with higher trait resilience (Genet & Siemer, 2011). However, this study did not directly assess attentional control and also did not assess emotional responses to a laboratory stressor.

Given that attentional control decreases in acute and chronic stress (Gray et al., 2009; Plessow et al., 2011a, Plessow et a., 2011b) and that higher control often is needed in such situations (Goeschke, 2010), preserved affective control in stressful situations might be characteristic of resilience.

Our results are also in line with earlier findings showing that failure to recruit affective control in response to conflict is related with stress-related disorders such as anxiety (e.g., Bishop, 2009) and depression (Joorman & Gotlib, 2010). Prior studies showing that lower attentional control (assessed with self-report measures) is related with increased worry and intrusions in response to stressors (e.g., Hagenaars & Putman, 2011; Verwored et al., 2008) indicate that failure to recruit affective control seriously affect emotion regulatory abilities. The failure to recruit affective control in depression might be related problems with terminating negative thoughts and emotions that constitute hallmarks of this disorder (Goeschke, 2014).

Our results indicate that increased affective control leads to increased resilience. This finding has important clinical implications, because training to increase affective control could prove an important prevention and treatment of stress-related disorders. A recent study showed that computerized training result in increases in affective control (Schweizer, Grahn, Hampshire, Moobs, & Dalgleish, 2013), and such interventions could provide a cost-effective option for stress prevention. However, current findings are preliminary, and more research with both healthy and psychopathological groups is needed before such trainings can be recommended.

6.3 Methodological considerations

The designs of the presented studies have both methodological strength and limitations. After a general discussion concerning aspects related to all the presented studies, methodological strengths and weaknesses are discussed separately for the respective studies.

6.3.1 General methodological discussion. In all the presented studies, healthy participants were investigated. Research with healthy participants has been strongly suggested for two reasons; (1) basic research about selective attention to emotional stimuli in healthy participants is lacking and (2) to aid the identification of protective selective attention to emotional stimuli (Yiend, 2010). The results from these studies might thus contribute to clarification of what patterns of selective attention that might be related with resilience. By providing useful information about the character of selective attention in resilient individuals, our result might guide the development of prevention and treatment paradigms.

Two of the conducted studies presented in this thesis used a cross-sectional design. Studies with such designs cannot deliver causal evidence. In both the cross-sectional studies, the attentional parameter (i.e., biased attention to positive stimuli, affective control) was associated with higher trait resilience. Because of the study design, we cannot exclude the possibility that these attentional parameters are markers, but not precursors of trait resilience. Further studies with longitudinal designs are needed to investigate if biased attention to positive stimuli and affective control are predictors or markers of resilience. Longitudinal studies with baseline measures of resilience and attentional parameters, followed by multiple repeated measures of resilience over time would be suitable to explore causality. Alternatively, experimental studies including induction of biased attention or affective control can be conducted, with follow up measurement of stress reactivity.

Further, in two studies we used a self-rating measure of trait resilience that is cost-effective. However, other measures of resilience, such as physiological markers, could shed light over additional aspects of individual differences in stress resilience.

6.3.2 Methodological consideration article 1. In an experimental study 43 healthy participants completed a self-report measure of trait resilience together with a modified dot probe task measuring biased attention to emotional stimuli. The relatively cost- and time effective design enabled a throughout investigation into methodological issues such as stimuli presentation and target detection difficulty. The investigation was conducted as a row of smaller pilot studies preceded the actual study. In these pilot studies, methodological aspects of the stimuli presentation (e.g., presentation time) in the dot probe task were varied and the result evaluated, contributing to considerable improvement of the initial behavioral task.

6.4.3 Methodological consideration article 2. We conducted two experimental studies assessing affective control with a behavioral task (i.e., modified emotional Stroop task). In the first study 48 healthy participants completed a self-rating of trait resilience, and in the second study 61 healthy female participants completed self-ratings of emotional responses before and after a laboratory stressor (i.e., stressful film sequence).

A major strength of these studies was the interpretation of the behavioral data under the assumption of conflict adaption. However, it is important to note that both conflict adaptation (Botvinick et al., 2001) and feature integration (Hommel et al., 2004) effects might contribute to the congruency-sequence effects that were used in our study to index affective control affective control (Egner, 2007). On the other hand, a recent literature review pointed out that in previous studies, the results with Stroop tasks have mainly been driven by conflict adaptation, speaking for that our results reflect mainly conflict adaptation (Egner, 2007). Future studies with this behavioral task could include more trials, thus enabling modeling of eventual feature integration effects.

Regarding the second study, we included only female participants. This limits the interpretation of the result in the general population, and the result should be replicated in male participants.

In the second study, we assessed emotional reactions with self-rating questionnaires. Other measures of emotion, such as quantification of facial expressions in response to the film sequence, might have provided a more objective measure of emotional reactions.

6.4 Conclusions and directions for future research

To the best of our knowledge, ours were the first studies to directly investigate how stress resilience is related to biased attention to emotional stimuli and affective control. In conclusion, our findings suggest that higher biased attention to positive stimuli and higher affective control are related with stress resilience.

Future research should replicate these results, and investigate in more detail what neurological processes underlie biased attention to emotional stimuli and affective control, and how these relate with stress resilience.

Further investigation is needed into the many methodological questions that remain open pertaining to biased attention in healthy and psychopathological populations. Such methodological research is almost completely lacking with positive stimuli, and it is not well known how variations in stimuli intensity and current mood impact biased attention to such stimuli. Studies with larger cohorts of participants are needed to conclude if individual differences in resilient outcome suggested by prior research are reflected in ABs.

To assess how differences in biased attention and affective control are influenced by situational variation in stress, future studies should be conducted under varying levels of situational stress. Studies in stressful situations might reveal important information about the role of selective attention to emotional stimuli that cannot be captured in non-stressful situations.

To identify the character of selective attention associated with highly resilient outcome, studies should include highly resilient individuals. The question how to identify such individuals remains partly opens, but an ideal study design might include measurement of functioning before and after one or several severe stressors, or multiple assessments before and during chronic stress. Individuals that under such circumstances do not exhibit decreases in functioning might give clues to factors contributing to a resilient outcome.

Research is also needed into how to distinguish degrees of resilient outcomes, as most research focuses on the absence of psychopathology or preserved functioning. More sensitive measure, be it in the form of neural markers or questionnaires, are needed to capture degrees of resilience in the non-pathological group.

Chapter 7 - Concluding remarks

The work presented in this thesis explored that two parameters of selective attention to emotional stimuli, i.e. biased attention to emotional stimuli and affective control, might underlie stress resilience and stress-related disorders.

This work has been performed under the premises of (i) biased competition and (ii) conflict adaptation:

(i) Biased attention arises from individual differences in bottom-up and top-down representations. Individual differences in stress resilience arise from differences in biased attention that results from interactions between environmental input and the individual's representation of the environment.

Both individual differences in bottom-up and top-down representations of emotional stimuli might contribute to resilience outcome.

(ii) Affective control varies with the level of conflict in the previous and current situation. This means that individual differences in adaptation (i.e., conflict detection and exhibition of top-down control) to conflict in an emotional context give rise to differences in resilient outcome.

The research described in this thesis provides (1) experimental evidence for an association between higher biased attention to positive stimuli and higher self-rated resilience, and (2) experimental evidence for an association between higher affective control and higher self-rated trait resilience, and (3) evidence for that higher affective control predicts better emotion regulation in response to a laboratory stressor. This thesis is based on the following publications numbered from I-II (see below). These publications comprise original research described in the previous chapters of this thesis (Chapters 5).

7.1 Summary of original contributions

The original contributions of this thesis are summarized as follows:

• The experimental study expanded on prior knowledge about the relationship between biased attention to positive stimuli and stress resilience. (Publication I).

• A modified dot-probe task was developed and used, that enables measurement of accuracy biases in addition to ABs in RT. (Method, publication I)

• The second and third experimental studies expanded prior knowledge about the relationship between affective control and stress resilience (Publication II)

7.2 Publications arising from work in this thesis

In submission:

I. Thörn, H., Grushow, M., Ruff, C., Ehlert, U., & Kleim, B. Attentional bias to positive stimuli predicts stress resilience.

II. Thörn, H., Grushow, M., Ruff, C., Ehlert, U., & Kleim, B. Affective control predicts stress resilience.

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Appendix

Appendix I *Affective and motivational correlates of attentional bias to positive stimuli using a Dot Probe task*

Authors	Participants	Positive stimuli[a]	Presentation duration (ms)[a]	Affective, stress or motivational measure[b]	AB association with affective, stress or motivational measures[c]
Mood					
Tamir & Robinson, 2007, study 1	Healthy (*N*= 95)	Positive words	500	Positive mood[d]	AB ↑ positive mood, *t*(94)=2.63, β =.27**
Tamir & Robinson, 2007, study 2	Healthy (*N*= 85)	Reward words	300 & 900	Positive mood[d]	AB ↑ positive mood, *F*(1,82)=8.40***
Tamir & Robinson, 2007, study 3	Healthy (*N*= 68)	Positive words	700	Positive mood[d]	AB ↑ positive mood, *F*(1,67)=5.72*
Tamir & Robinson, 2007, study 4	Healthy (*N*= 43)	**Reward words, high** or low arousal	600	Positive mood[d]	AB ↑ positive mood, *F*(1,44)=4.84*
Tamir & Robinson, 2007, study 5	Healthy (*N*= 74)	**Reward words, high** or low arousal	700	Positive mood[d]	AB ↑ positive mood, *F*(1,73)=12.38**
Stress					
Fox et al., 2010	Healthy, baseline (*n*= 104), 4 months (*n*= 82) 8 months (*n*= 70)	Positive images	**Masked 14**, 300	NEO-FFI	AB ↓ higher neuroticism, *r*(102)=-.22*
			Masked 14, 300	STAI-S	AB ↑ lower state ANX during laboratory stressor 4 months post, *r*(82)=-.25*
Johnson, 2009	AB instruction group (*n*= 54), C (*n*= 55), (N = 109; 42 ♂ 67 ♀)	Happy faces	17, 500, **1250**	Frustration (Likert scale) during – before stressor	AB instruction ↓ frustration *F*(1,53)= 4.41*
			17, **500,** 1250	Persistence anagram task	AB ↑ longer persistence, *r*(53) = .29*

			17, 500, **1250**	Persistence anagram task	AB ↑ longer persistence, *r*(53) = .32*
Taylor et al., 2010	"individuals with difficulty giving speeches (*N*= 43; 13 ♂ 30 ♀)	Positive social words	500	LSAS-SR	AB ↑ lower social ANX , *r*(43)= -.41**
					AB ↑ lower state ANX baseline, *r*(43)= -.31* AB ↑lower ANX during speech, *r*(43)= -.49***
					AB ↑ lower ANX during speech, controlling for social anxiety, *β* = −.31, *t*(42) = −2.02*
Motivation					
Schultheiss & Hale, 2007, study 1	Students (*N*= 52; 23 ♂ 29 ♀)	**Joyful** and surprised faces	Masked 12, 116 & 231	SC Implicit motives: affiliation	AB ↑ higher affiliation motivation, *B*=0.91, *r*=.31*
Schultheiss & Hale, 2007, study 1	Students (*N*= 60; 29 ♂ 31 ♀)	**Joyful** and surprised faces	Masked 12, 116, 231	SC implicit motives	No association

Note: N= Negative; NE= Neutral; P= Positive; H= Happy; A= Angry; LSAS-SR, Liebowitz Social Anxiety Scale- self report (Liebowitz, 1987); SC, self constructed; NEO-FFI, NEO personality Inventory, (Costa & McCRae, 1985); STAI, State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushen, 1983).

[a] Some studies used several stimuli conditions, in such cases the result relevant presentation time is in boldface. In some studies, all trials were added up into one AB score, in such cases both presentation times are in boldface.

[b] Main outcome variables relevant for results with AB to positive stimuli.

[c] All results pertaining to AB to positive stimuli; Significance level as indicated: *<0.05, **<0.01, ***<0.001.

[d] Mood as follows: study 1, naturalistic mood measurement over a week; study 2, sad, neutral, and happy mood induction; study 3, anxious and positive mood induction; study 4, negative and positive visual mood induction; study 5, negative and positive music induction.

[e] fMRI study, fMRI results reported in the neural chapter.
[f] In contrast with other studies in this table, this study included both adult and child participants (9-40 yrs).

Appendix II *Clinical correlates of attentional bias to positive stimuli using a Dot-Probe task*

Authors	Participants	Positive stimuli	Presentation duration[a] (ms)	Clinical measures[b]	AB association with clinical measure[c,d]
Clinical Anxiety					
Bradley & Mogg, 1999	GAD *n*= 14; 7 ♂ 7 ♀), HC *(n*= 33; 13 ♂ 20 ♀)	Happy faces	500,**1250**	n.n.	AB ↑GAD (*F*(1,45)= 15.75*)
Deperro et al., 2013	PTSD (*N*= 27 ♀ 27)	Positive words	1000	PCL	No association
Fani et al., 2010	PTSD symptoms (*N*=129; 37 ♂ 92 ♀)	Happy faces	500	PSS, CTQ	AB ↑ childhood maltreatment (*r*= .25**) AB ↑ avoidance and numbness (*r*= .19*)
Mogg et al., 2004	Social ANX (*n* = 15, 8 ♂ 7 ♀), HC (*n*= 15; 8 ♂ 7 ♀)	Happy faces	500,1250	MINI, FNE, BDI	AB ↓ than AB to angry in ANX (*t*(13)= 2.58*) AB ↓ANX (*d*=-.62) AB ↓MDD (*d*= -.58*)
Stevens et al., 2009[e]	Social phobia *(n*= 40; 16 ♂ 24 ♀), HC (*n*= 40)	Happy faces	175,600	SCID	No association
Non-clinical anxiety in student populations					
Bradley et al., 1998	High ANX (*n* = 20), low ANX (*n*= 20)	Happy faces	**500**, 1250	POMS (ANX, MDD, vigor), STAI-T, SDS, BDI	AB ↓ ANX (*t*(36)=2.58*) AB ↓than zero ANX (*t*(18)= 2.20*) AB ↓trait ANX (*r*= -.32*) AB ↓MDD (*r*= -.43*)
Brosschot et al., 1999	Low MCS/low ANX (*n*= 15), low MCS/ high ANX (*n*= 15), high MCS/ high ANX	Positive words	500	STAI, MCS	No association

	(*n*= 15), low MCS/ low ANX (*n*= 10), low MCS/ high ANX (*n*= 8), (*N*= 69; 19 ♂ 50 ♀)				
Dewitte et al., 2007	High/low ANX (*N*= 39; 7 ♂ 32 ♀)	Positive words	500	ECR-r	No association (F(1,44)= 0.00, *d*= .00)
Eldar et al., 2010[ŧ]	ANX (*N*= 23; 6 ♂ 17 female), low-ANX (*N*= 23; 10 ♂ 13 ♀)	Happy faces	500	STAI	No association
Fox, 2002, study 1	High/low ANX (*N*= 32; 12 ♂ 20 ♀)	Happy faces	500	STAI	AB ↓ ANX in LVF than low ANX (*t*(30) = 1.83*) AB ↓ ANX than zero (*t*(15) = 2.03*)
Fox, 2002, study 2	High ANX (*n*= 18), low ANX (*n*= 18) (N= 36, 10 ♂ 26 ♀)	Happy faces	Masked 17	STAI	AB ↑low ANX in RVF (*t*(17)= 2.1*)
Keogh et al., 2001	High/ low physical ANX (*N*= 100; 20 ♂ 80 ♀)	Positive words	500	physical ASI	AB ↓ANX, AB ↑ low ANX (*F*(1,49)=4.08*)
Mansell et al., 1999	High FNE and threat (*n*= 15, 5 ♂ 13 ♀), low FNE and threat (*n*= 16, 8 ♂ 8 ♀), high FNE no threat (n= 20; 7 ♂13 ♀), low FNE no threat (*n*= 20; 9 ♂ 11 ♀)	Positive faces	500	FNE	AB ↓ emotional faces (incl. negative) ANX (*t*(29)= 3.0**)
Mogg & Bradley, 1999	High/ low MD / ANX (*N*= 35)	Happy faces	Masked 14	FNE, POMS	No association
Pishyar et al., 2004, Study 1	High /low social ANX (*N*= 33; 5 ♂ 28 ♀)	Positive words	500	FNE	No association
Pishyar et al., 2004 Study 2	High/low social ANX (*N*= 29; 5 ♂ 24 ♀)	Positive face	500	FNE	AB ↑ low ANX (F(1,31)= 3.82*)

		profiles[g]			
Shrootens & Smulders, 2010	High ANX (*n*= 24), low ANX (*n*= 26)	Positive words	14, **500**	STAI, MCS	AB ↑ANX (F(1,45)= 4.0*)
Vassilopoulos, 2005	High ANX (*n*= 26; 2 ♂ 24 ♀)/ low ANX (*n*= 26; 9 ♂ 17 ♀)	Positive words	200, 500	FNE	No association
Yu et al., 2013	ANX (*n*= 11 ♂ 7 ♀), HC (*n*= 9 ♂ 8 ♀)	Positive social words	**100,** 500, 1250	FNE	AB ↓ ANX than HC ($t(33) = 3.06$, $p < .01$, $d= 1.03$)
Clinical depression					
Gotlib et al., 2004	MDD (*n*= 19), GAD (*n*= 18), HC (*n*= 16), all ♀	Positive faces	1000	SCID	AB ↓ than AB to sad in MDD ($t(18)$=1.19*)
Mingtian et al., 2011[t]	MDD (*n*= 24; 7 ♂ 18 ♀), never- MDD (*n*= 24; 7 ♂ 18 ♀)	Positive images	100, **500**		AB ↑never MDD ($t(47)$= -4.69***)
Non-clinical depression					
Shane & Peterson, 2007, study 1	High/low DYS (*N*= 97; 29 ♂ 66 ♀)	Positive images	**500, 1500**	BDI, differential AB scores (AB to positive – AB to negative),	AB ↑ in non-DYS ($t(70)$=2.13, d=.50*) AB ↓ DYS (β =-.28*)
Shane et al., 2007, study 2	High/low DYS (*N*= 81; 30 ♂ 51 ♀)	Positive words	**200, 1500**	BDI, differential AB scores (positive – negative)	AB ↓DYS ($t(25)$=2.51, d=.55*) AB↑ non-DYS ($t(63)$=3.39, d=.85**) AB ↑ lower DYS (β =-.26*)
Depression vulnerable population					
Chan et al., 2007	High-neurotic, never MDD (*n*=33; 11 ♂ 22 ♀), low-neurotic (*n*= 32; 14 ♂ 18 ♀)	Positive words	Masked 14, 500	EPQ	No association

Bipolar disorder					
Jabben et al., 2012	Bipolar (*N*= 77), euthymic (*n*= 60), MDD (*n*= 17), first-degree relatives (*N*= 39), HC (*N*= 61)	Positive words	500	n.n	AB ↓ MDD than relatives (*p*= .02), HC (*p*= .013), euthymic (*p*< .01)
Jongen et al., 2007	Bipolar: mild MDD (*n*= 16; 9 ♂ 7 ♀), euthymic (*n*= 13; 6 ♂ 7 female), HC (*n*= 29)	Positive words	500	HRSD, YMRS	AB ↓to emotional (incl. negative) MDD (F(1,30)=5.1, *p*= .03, n^2=14)

Note: GAD, Generalized Anxiety Disorder; ANX, Anxiety; MDD, Major Depression Disorder; DYS, Dysphoria; LVF, left visual field; RVF, right visual field; HC, healthy control.

In alphabetic order: ASI, Anxiety Sensitivity Index (Reiss, Peterson, Gursky, & McNally, 1986); BDI, Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; CTQ, the Childhood Trauma Questionnaire (Bernstein & Fink, 1998); ECR-r, the Experiences in Close; Relationships Scale revised (Fraley, Waller & Brennan, 2000); EPQ, Eysenck Personality Questionnaire (Eysenck & Eysenck, 1985); FNE, Fear of Negative Evaluation (Watson & Friend, 1969); HRSD, Hamilton Ratings Scale Depression (Hamilton, 1960); LSAS, Liebowitz Social Anxiety Scale (Liebowitz, 1987); MCS, Marlow Crow Social Desirability Scale (Hermans, 1967); MINI, Mini International Neuro-psychiatric Interview (Lecribier, Weiller, Bonara, Amorine, & Lépine, 1994); PCL, Posttraumatic Stress Disorder Checklist (Weathers, Litz, Herman, Huska, & Keane, 1993); POMS, Profile of Mood States (McNair, Lorr, & Droppleman, 1981); PSS, modified PTSD Symptom Scale (Falsetti, Resnick, Resik, & Kilpatrick, 1993); SCID, Structured Clinical Interview for the DSM IV (Wittchen, Wunderlich Gruschwitz., & Zaudig, 1997); SDS, Social Desirability Scale (Crowne & Marlowe, 1964); STAI-T, State Trait Anxiety Inventory (Spielberger, Gorusch, & Lushene, 1983); YMRS, Young Mania Rating Scale (Young, Biggs, Ziegler, & Meyer, 1978).

[a] Some studies used several stimuli presentation times, in such cases the result relevant presentation time is in boldface. In some studies, all trials were added up into one AB score, in such cases both presentation times are in boldface.

[b] Main outcome variables relevant for results with AB to positive stimuli.

[c] All results pertaining to AB to positive stimuli; Significance level as indicated: *<0.05, **<0.01, ***<0.001.

[d] AB to negative or other stimuli mentioned only when compared with AB to positive stimuli.

[e] The study, Stevens et al., 2009, included the conditions before/after drinking alcohol/orange juice.

[f] EEG study

[g] Half of the profiles were images of the participant self.

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Assistant psychologist	Southern inner city psychology team Malmö city, Malmö, Sweden	Jan.-June 2005
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